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TECHNICAL SUPPORT DOCUMENT

AIRCRAFT/AIRPORTS

CALIFORNIA FIP IFR

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Prepared for:

U.S. ENVIRONMENTAL PROTECTION AGENCY
MOTOR VEHICLE EMISSION LABORATORY
Ann Arbor, MI

Prepared by:

ENERGY AND ENVIRONMENTAL ANALYSIS, INC.

1655 North Fort Myer Drive, Suite 600
Arlington, Virginia 22209

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1. INTRODUCTION

1.1 FEDERAL IMPLEMENTATION PLAN (FIP) BACKGROUND

This document presents technical supporting data used by EPA in developing the interim final Federal Implementation Plan control strategy for aircraft operations in the Los Angeles, Sacramento, and Ventura areas of California.

The Clean Air Act and its various amendments established National Ambient Air Quality Standards (NAAQS) for several "criteria" pollutants, including ground-level ozone. Regions of the nation that fail to attain any of these standards are subject to a series of rigorous requirements designed to achieve attainment with the NAAQS. Three regions in California have failed to attain the NAAQS for ground-level ozone by a wide margin. The South Coast Air Basin of California, encompassing the Los Angeles metropolitan area and surrounding communities, has been designated as being in Extreme nonattainment. Ventura County has been designated as being in Severe nonattainment. The Sacramento Air Basin, encompassing the Sacramento metropolitan area and surrounding communities, has been redesignated from Serious nonattainment to Severe nonattainment for ozone. This will provide the area with additional time to achieve attainment, since the redesignation changes Sacramento's attainment date from 1999 to 2005.

EPA proposed a Federal Implementation Plan (FIP) for the three control areas to ensure that the control areas achieve timely compliance with the ozone NAAQS. The FIP proposal included measures to reduce air pollutant emissions from sources associated with airport operations in the FIP areas. EPA published the proposed FIP control program in the *Federal Register* on May 5, 1994 (59 FR 23355, May 5, 1994) and invited public comment on all aspects of the proposal; the public comment period closed on

August 31, 1994. Comments were received on the portion of the program dealing with aircraft operations from a broad spectrum of concerned parties, including federal, state, and local government agencies, airport operating authorities, industry representatives, trade associations, and private citizens. EPA reviewed these comments and developed an interim final rule (IFR) that includes a modified control program for aircraft operations.

1.2 STATUS OF THE AVIATION INDUSTRY

Aircraft operations can be segregated into four general categories:

- Commercial -- aircraft operated on a scheduled basis by international, national, regional, and commuter air carriers, and unscheduled charter operators
- Military -- aircraft operated by the Department of Defense (DoD)
- General Aviation -- aircraft privately owned and operated on a nonscheduled basis
- Public -- aircraft operated by federal, state, or local government agencies other than the military

The Code of Federal Regulations (CFR) Title 14: Aeronautics and Space (Reference 1) includes rules issued by the Federal Aviation Administration (FAA) of the Department of Transportation (DOT) under Chapter 1. Subchapter F contains information on air traffic and general operating rules for all aircraft operations. Subchapter G provides information on certification and operations of air carriers, air travel clubs, and operations for compensation or hire.

Commercial aviation includes all aircraft operations conducted by "commercial aircraft" operators. For purposes of this document, a "commercial aircraft" operator is defined as an operator who at any time conducts operations under 14 CFR Subchapter G Part 121 (Domestic, Flag, and Supplemental Air Carriers and Commercial Operators of Large Aircraft); 125 (Airplanes Having a Seating Capacity of 20 or More Passengers or a Maximum Payload Capacity of 6,000 Pounds or More); 127 (Scheduled Air Carriers With Helicopters); 129 (Foreign Air Carriers and Foreign Operators of U.S.-Registered Aircraft Engaged in Common Carriage); or 135 (Air Taxi Operators and Commercial Operators). Commercial aircraft are discussed in Section 2 of this document.

General aviation includes all aircraft operations conducted by "general aviation aircraft" operators. For this document, a "general aviation aircraft" operator is classified as an operator who only conducts operations under 14 CFR Subchapter F, Part 91, Subchapter G Part 133 (Rotorcraft External-Load Operations); or 137 (Agricultural Aircraft Operations), as well as those persons who operate aircraft under Subchapter F Part 101 (Moored Balloons, Kites, Unmanned Rockets, and Unmanned Free Balloons); 103 (Ultralight Vehicles); or 105 (Parachute Jumping).

Military aviation for the purposes of this document includes all aircraft operations under the control of the DoD. This encompasses aircraft and related ground equipment operated by Air Force, Navy (including Marines), Army, and associated National Guard and Reserve units. Military aviation includes the full spectrum of aircraft types, ranging from high-performance jet fighters to large transports to small piston-engine aircraft. These aircraft are operated in a highly variable manner dependent upon specific mission requirements, and therefore are much more difficult to characterize than scheduled commercial air carrier operations. Most military aircraft operations occur at DoD-operated air bases, but certain operations can take place at civilian airports as well. Examples of such activity include National Guard aircraft based at a civilian facility and military transports shuttling personnel to a civilian airport.

Aircraft operated by non-DOD government agencies such as the Coast Guard, which is part of the Department of Transportation, or local police departments are considered to be "public aircraft" for the purposes of this document.

Aircraft in each category are operated in considerably different fashions; commercial aircraft operate on a relatively fixed schedule while military aircraft operate according to specific mission requirements, for example. Aircraft are operated at a wide variety of locations in the control areas; see EEA's *Technical Support Document, Civil and Military Aviation, California FIP, NPRM*, dated March 24, 1994 (hereinafter referred to as the "1994 TSD") (Reference 7) for listing of airports in the FIP control areas that had fixed-wing aircraft operations in 1991. In addition to these civil airfields, the FAA list for 1991 showed 198 helipads in the South Coast control area, 11 helipads in the Sacramento control area, and 12 helipads in the Ventura control area; this includes private helipads, medical facilities, and various local government facilities. According to 1990 operations data, 14% of total operations in the South Coast Air Basin were commercial (as defined above), 5% military, and 81% general aviation. No detailed operations data are available for public aircraft. For the Sacramento Air Basin the operations breakdown was 23% commercial, 19% military, and 58% general aviation. For Ventura County the split was 8% commercial, 13% military, and 79% general aviation.

Air pollutants resulting from airport operations are emitted from several types of sources: aircraft main engines and auxiliary power units (APUs); ground support equipment (GSE), including vehicles such as aircraft tugs, baggage tugs, fuel trucks, maintenance vehicles, and other miscellaneous vehicles used to support aircraft operations; and ground access vehicles (GAV), which include vehicles from off-site used by passengers, employees, freight operators, and other persons utilizing an airport.

Aircraft engines comprise approximately 44% of total air pollutant emissions from airport operations in the FIP areas as a group; GAV account for another 44%, and

APUs and GSE combined make up the remaining 12%. As discussed in this document, total (HC + NO_x) emissions from aircraft (commercial, military, and general aviation) currently contribute an estimated 0.9% of the South Coast Air Basin's emissions inventory, 0.9% of the Sacramento Air Basin's emissions inventory, and 0.4% of Ventura County's emissions inventory. In the South Coast Air Basin there are five commercial airports: Burbank, John Wayne, Long Beach, Los Angeles International and Ontario International Airports. Aircraft operating at these five commercial airports alone contributed 0.3 and 1.1 percent of the total 1990 baseline emissions inventory for VOC and NO_x, respectively. At projected growth rates, aircraft at these five airports will consume nearly 3.9 and 4.4 percent of the basin's allowable 2010 NO_x and VOC inventory, respectively, if left uncontrolled.

1.3 SCOPE OF THE TECHNICAL SUPPORT DOCUMENT

This document discusses technical information used by EPA during its development of the interim final FIP control strategy for aircraft operations. This technical information includes aircraft and APU operations and emissions data, as well as operations and emissions data for various types of ground equipment associated with aircraft operations. Commercial aviation emission sources, described in Section 2, are affected by the IFR as follows: the proposed bubble strategy for commercial aircraft has been dropped in favor of command-and-control measures designed to reduce emissions from GSE and APUs that support commercial aircraft operations. The new measures for reducing GSE and APU emissions show much smaller benefits than the targets of the bubble strategy, however, the savings due to lower fuel and maintenance costs under the command and control requirements result in overall cost savings. General aviation sources, discussed in Section 3, have been dropped from the control strategy. Military aviation sources and public aviation sources have been dropped from the control strategy and are not discussed further in this document.

2. PROGRAM ELEMENT: COMMERCIAL AVIATION

2.1 COMMERCIAL AVIATION CHARACTERIZATION

Commercial aircraft are operated on a scheduled basis by international, national, regional, and commuter air carriers, and on an unscheduled basis by air taxi charter operators. Commercial aircraft are defined for the purpose of this control strategy as those aircraft operating under any of the following Federal Aviation Administration (FAA) operational classifications:

Part 121: Domestic, flag, and supplemental air carriers and commercial operators of large aircraft

Part 125: Airplanes having a seating capacity of 20 or more passengers or a maximum payload capacity of 6000 pounds or more (and not operated under Parts 121, 135, or 137)

Part 127: Scheduled air carriers with helicopters

Part 129: Foreign air carriers and foreign operators of U.S.-registered aircraft engaged in common carriage

Part 135: Air taxi operators and commercial operators

Emissions sources associated with commercial aircraft operations are concentrated in several specific locations in the control areas. The South Coast Air Basin has five major commercial airports (Los Angeles, Ontario, Burbank, John Wayne, and Long Beach). The Sacramento Air Basin includes a single commercial airport, while the Ventura control area has only minimal commercial aviation activity. (See EEA's *Technical Support Document, Civil and Military Aviation, California FIP, NPRM*, dated March 24, 1994 (hereinafter referred to as the "1994 TSD") (Reference 7) for a list of airports in the respective control areas at which commercial aircraft operated in 1990.)

In addition to aircraft, emission sources related to commercial aircraft operations include aircraft auxiliary power units (APUs), and ground support equipment (GSE). APUs are used at an airport to supply electrical power and air-conditioning to aircraft when the aircraft engines are not operating. GSE includes vehicles such as aircraft tugs, baggage tugs, fuel trucks, maintenance vehicles, and other miscellaneous vehicles. To include the greatest number of emissions sources in this component of the control strategy, mobile sources not owned by but under the control of commercial aircraft operators were included. Mobile sources considered to be "under the control" of a commercial aircraft operator were all sources owned or leased by the aircraft operator, and all sources whose operations are controlled under a contract agreement by the aircraft operator. For example, some GSE that service commercial aircraft are owned by fixed base operators (FBOs) rather than airlines; emissions from these vehicles are considered to be under the control of the airlines since their operations are a direct result of aircraft activity.

Ground access vehicles (GAV) include vehicles used by passengers, employees, freight operators, and other persons using an airport. Commercial airlines have only limited authority or control over GAV so these sources were not considered in this control strategy. Also, the South Coast Air Quality Management District has proposed a program for the Los Angeles area to reduce emissions from these sources.

Section 2.2 summarizes the original proposed control strategy for commercial aircraft operations. Section 2.3 discusses the data, data sources, and methodologies used by EEA in developing the baseline and forecasted emissions inventories for APUs and GSE in support of EPA's interim final control program.

2.2 SUMMARY OF ORIGINAL PROPOSAL

Emissions sources associated with commercial aircraft are concentrated in several specific locations in the control areas. The South Coast Air Basin has five major commercial airports (Los Angeles, Ontario, Burbank, John Wayne, and Long Beach). The Sacramento Air Basin includes a single commercial airport, while the Ventura control area has only minimal commercial aviation activity.

The proposed control strategy for commercial aircraft operations established a very broad and aggressive market-based system of specific emission reduction targets to be achieved through various emission reduction measures implemented at the regulated community's discretion, within an overall regulatory framework established by the EPA. The proposed strategy addressed the emissions from main aircraft engines, APUs, and GSE. Any GAV emissions reduction programs will be implemented by the local air quality management districts. An alternative approach considered at the time of the original proposal was the development of command-and-control mandates, but such mandates were considered poorly suited to aircraft operations because of the highly variable nature of factors affecting potential emission reduction measures available to aircraft operators.

The proposed control program therefore relied on a bubble concept for reducing emissions resulting from commercial aircraft operations in the control areas. Under the proposed program, commercial aircraft operators were required to achieve a series of declining emissions targets over the attainment demonstration period. These targets included emissions from operations of aircraft engines, APUs, and GSE, and were expressed in terms of pounds of emissions per "passenger equivalent unit (PEU)." These targets were based on emissions reduction objectives consistent with the stationary source cap program proposed elsewhere in the FIP, with reduction ranges of 25-45 percent for VOC emissions and 35-45 percent for NO_x emissions from a 1990 baseline. Such emissions reductions were ambitious, particularly in light of the increased emissions expected to result from forecasted growth in control-area air traffic during the control period.

The pounds-per-PEU targets included in the proposed control program were derived from limited, summary data available to EPA at the time of the proposal's development. The proposed program provided for EPA to calculate final targets based on required reports from commercial aircraft operators of emissions data for a designated baseline year. Compliance with these final targets was then to be assessed on a seasonal basis using compliance reports submitted by the regulated community. The proposed program did not mandate specific emissions reduction measures to be taken by commercial aircraft operators, who were free to reduce their emissions using methods that best suited their particular requirements.

EPA designed the proposed control program to account for the many unique market, technological, and safety factors that affect commercial aircraft operations. The program thus represented an innovative effort at controlling air pollutant emissions from a largely heretofore uncontrolled emissions source category.

2.2.1 1990 Inventory for Original Proposal

Any emissions reduction program fundamentally requires a starting point from which progress towards attainment can be tracked and verified. Such a baseline is particularly important in a control program that relies upon a series of intermediate targets, since these targets must be calculated on a consistent basis for all affected sources. The Clean Air Act requires EPA to establish emission reduction targets from 1990 emission levels.

In the 1994 TSD (Reference 7), commercial aviation activity, which is indicative of emissions, was evaluated over a several-year period to consider whether 1990 was a suitable baseline period for the proposed control program. No effects that would make 1990 appear unrepresentative of typical aviation activity during this period were identified. Baseline emissions calculations therefore were made for 1990 aircraft main engines, auxiliary power units, ground support equipment, and ground access vehicles (excluded from the proposed control strategy). The following sections present summary data from these calculations; see the 1994 TSD for a detailed discussion of the calculation methodology and data inputs used in this analysis.

2.2.1.1 Aircraft

Commercial aviation in the affected control areas includes all types of air carriers plus air taxis. Emissions inventories for aircraft and related equipment fundamentally rely on the concept of a landing-takeoff operation (LTO) cycle.

The total emissions of aircraft main engines from commercial aircraft for each airport were calculated for the 1994 TSD by estimating the emissions for each air carrier aircraft type, totalling these aircraft emissions for all air carrier aircraft, and adding the total emissions for all air taxi aircraft. To calculate the total emissions from commercial aircraft the following data were necessary: air carrier aircraft type, air carrier aircraft LTOs, air carrier engine emission factors, air carrier aircraft times in mode, air taxi activity, and air taxi emission factors. Figure 2-1 presents a summary of commercial aircraft emissions and LTOs by airport.

2.2.1.2 Auxiliary Power Units

An APU, which is a component of a large aircraft, is essentially an on-board small turbine engine. If a ground-based power or air source is unavailable, the APU is operated when the aircraft is on the ground with its engines shut down. An APU generates electricity and compressed air to operate the aircraft's instruments, lights, ventilation, and other equipment.

The total emissions from commercial APUs for each airport were calculated for the 1994 TSD by estimating the APU time in mode, the emissions from APUs for each aircraft

FIGURE 2-1: SUMMARY OF 1994 TSD COMMERCIAL AIRCRAFT LTOs AND EMISSIONS - 1990 (lb/yr)

SOUTH COAST AIR BASIN			
Airport	**LTOs**	**HC**	**NO_x**
Burbank	30,517	41,761	367,430
John Wayne	37,424	60,704	610,200
Long Beach	14,588	27,312	247,353
Los Angeles Intl	240,580	4,529,620	6,896,490
Ontario Intl	45,817	224,544	932,005
Air Taxi[1]	145,175	195,115	22,938
Basin Total:	514,101	5,079,056	9,076,416

SACRAMENTO AIR BASIN			
Airport	**LTOs**	**HC**	**NO_x**
Sacramento Metropolitan	39,722	107,818	544,968
Air Taxi[1]	27,758	37,306	4,386
Basin Total:	67,480	145,124	549,354

VENTURA COUNTY AIR BASIN			
Airport	**LTOs**	**HC**	**NO_x**
Oxnard/Ventura County	2,466	7,030	1,788
Air Taxi[1]	15,000	20,160	2,370
Basin Total:	17,466	27,190	4,158

Source: EEA memorandum *Technical Support Document Errata* (Reference 18)

[1] Air Taxi refers to the total air taxi emissions from all airports in the basin.

type, and totalling these APU emissions for all aircraft. To calculate the total emissions from commercial APUs the following data were used: aircraft, APU model, APU emission factors, aircraft LTOs, APU operating time, and information on the availability of fixed power and air systems at individual airport gates. Figure 2-2 presents a summary of APU emissions by airport.

2.2.1.3 Ground Support Equipment

A wide variety of equipment services commercial aircraft while they are unloading and loading passengers and freight at an airport. As a group, GSE include primarily the following equipment types: aircraft tugs, air start units, belt loaders, baggage tractors, air-conditioning units, ground power units, cargo moving equipment, and service vehicles. Buses, cars, pickups, and vans utilized in GSE operations were not included in the analysis. These vehicles were assumed to be licensed with the State of California and subject to stat and federal emissions regulations. As with APUs, air taxi and smaller air carrier aircraft do not require GSE.

GSE emissions were estimated for the 1994 TSD using a bottom-up approach. In this approach, emissions from each piece of equipment were calculated and then totaled for all GSE operating in the given inventory. The inputs to calculating emissions from GSE were population, horsepower, load factors, usage data, and emission factors. Figure 2-3 summarizes GSE emissions calculated for the 1994 TSD by airport.

2.2.1.4 Ground Access Vehicles (Excluded From Control Strategy)

Ground access vehicles (GAV) encompass all on-road vehicles operating on the airport grounds, including those used by passengers to access the airport. GAV include private automobiles, buses, taxicabs, and shuttles.

Emissions from GAV at several airports included in the 1994 TSD were taken from estimates provided by the airport. For airports that did not provide a GAV emissions

FIGURE 2-2: SUMMARY OF 1994 TSD COMMERCIAL APU EMISSIONS - 1990 (lb/yr)

SOUTH COAST AIR BASIN		
Airport	**HC**	**NO_x**
Burbank	1,207	19,783
John Wayne	759	21,576
Long Beach	692	8,092
Los Angeles Intl	5,507	131,403
Ontario Intl	2,289	31,484
Basin Total:	10,454	212,338

SACRAMENTO AIR BASIN		
Airport	**HC**	**NO_x**
Sacramento Metropolitan	1,064	16,217

NOTE: There are no APU emissions from the Ventura Air Basin since the smaller aircraft that operate there do not use APUs.

Source: 1994 TSD (Reference 7)

FIGURE 2-3: SUMMARY OF 1994 TSD COMMERCIAL GSE EMISSIONS - 1990 (lb/yr)

SOUTH COAST AIR BASIN		
Airport	**HC**	**NO_x**
Burbank	12,865	36,158
John Wayne	15,194	43,334
Long Beach	6,820	20,723
Los Angeles Intl	206,738	563,948
Ontario Intl	19,229	50,467
Basin Total:	260,846	714,630

SACRAMENTO AIR BASIN		
Airport	**HC**	**NO_x**
Sacramento Metropolitan	15,618	44,900

Source: EEA memorandum *Technical Support Document Errata* (Reference 18) estimate, a crude estimate was calculated based on various data including number of passengers and vehicle trips per passenger. A summary of the ground access vehicle emissions included in the 1994 TSD is presented in Figure 2-4.

2.2.1.5 Emissions Inventory Summary

Figures 2-5 and 2-6 summarize the 1990 commercial aviation emissions by airport and source as calculated in the 1994 TSD (Reference 7). Emissions sources covered are aircraft, APUs, GSE, and GAV. That inventory showed aircraft were the largest source of commercial aviation emissions as calculated in the 1994 TSD, with 49% of the total for the South Coast Air Basin, 53% for the Sacramento Air Basin, and 86% for the Ventura Air Basin.

2.2.2 Uncontrolled Forecasts

To appreciate the need for and impact of an emissions control strategy applied to aviation sources it is necessary to calculate an uncontrolled emissions forecast. Forecasts were developed for 2000, 2005, and 2010 for the South Coast Air Basin, 2000 and 2005 for the Ventura Air Basin, and 1999, 2000, and 2005 for the Sacramento Air Basin, and included in the 1994 TSD. The 2010 forecast in the South Coast control area, the 2005 forecast in the Ventura control area, and 1999 represented the attainment dates for each area as specified in the Clean Air Act Amendments (CAAA) of 1990. The 2005 forecast for Sacramento reflects the Sacramento control area's new attainment date. The growth rates for aircraft activity used for the 1994 TSD forecast calculations are discussed below as well as the forecasts of emissions for aircraft main engines, APUs, and GSE.

California Airports Growth Rates

The principal factor in forecasting emissions is the level of future aircraft activity. Several sources for growth rates were examined and compared in the 1994 TSD (Reference 7). Figure 2-7 summarizes the growth rates used to forecast airport activity.

FIGURE 2-4: SUMMARY OF 1994 TSD GROUND ACCESS VEHICLE EMISSIONS - 1990 (lb/yr)

SOUTH COAST AIR BASIN		
Airport	**HC**	**NO_x**
Burbank	408,800	613,200
John Wayne	441,946	662,919
Long Beach	132,860	199,290
Los Angeles Intl	4,920,000	4,888,000
Ontario Intl	510,997	678,325
Basin Total:	6,414,603	7,041,734

SACRAMENTO AIR BASIN		
Airport	**HC**	**NO_x**
Sacramento Metropolitan	108,000	434,000

VENTURA AIR BASIN		
Airport	**HC**	**NO_x**
Oxnard/Ventura County	2,081	3,122

Source: 1994 TSD (Reference 7)

**FIGURE 2-5: 1994 TSD HC EMISSIONS SUMMARY - 1990
COMMERCIAL AVIATION
(lb/yr)**

SOUTH COAST AIR BASIN					
Airport	**Aircraft**	**APUs**	**GSE**	**Vehicles[1]**	**Total**
Burbank	41,761	1,207	12,865	408,800	464,633
John Wayne	60,704	759	15,194	441,946	518,603
Long Beach	27,312	692	6,820	132,860	167,684
Los Angeles Intl	4,529,620	5,507	206,738	4,920,000	9,661,865
Ontario Intl	224,544	2,289	19,229	510,997	757,059
Air Taxi[2]	195,115	N/A	N/A	N/A	195,115
Basin Total:	5,079,056	10,454	260,846	6,414,603	11,764,959

SACRAMENTO AIR BASIN					
Airport	**Aircraft**	**APUs**	**GSE**	**Vehicles[1]**	**Total**
Sacramento Metropolitan	107,818	1,064	15,618	108,000	232,500
Air Taxi[2]	37,306	N/A	N/A	N/A	37,306
Basin Total:	145,124	1,064	15,618	108,000	269,806

VENTURA COUNTY AIR BASIN					
Airport	**Aircraft**	**APUs**	**GSE**	**Vehicles[1]**	**Total**
Oxnard/Ventura County	7,030	N/A	N/A	2,081	9,111
Air Taxi[2]	20,160	N/A	N/A	N/A	20,160
Basin Total:	27,190	N/A	N/A	2,081	29,271

Source: EEA memorandum *Technical Support Document Errata* (Reference 18)

[1] Excluded from the control strategy

[2] Air Taxi refers to the total air taxi emissions from all airports in the basin.

FIGURE 2-6: 1994 TSD NO_X EMISSIONS SUMMARY - 1990
COMMERCIAL AVIATION
(lb/yr)

SOUTH COAST AIR BASIN					
Airport	**Aircraft**	**APUs**	**GSE**	**Vehicles[1]**	**Total**
Burbank	367,430	19,783	36,158	613,200	1,036,571
John Wayne	610,200	21,576	43,334	662,919	1,338,029
Long Beach	247,353	8,092	20,723	199,290	475,458
Los Angeles Intl	6,896,490	131,403	563,948	4,888,000	12,479,841
Ontario Intl	932,005	31,484	50,467	678,325	1,692,281
Air Taxi[2]	22,938	N/A	N/A	N/A	22,938
Basin Total:	9,076,416	212,338	714,630	7,041,734	17,045,118

SACRAMENTO AIR BASIN					
Airport	**Aircraft**	**APUs**	**GSE**	**Vehicles[1]**	**Total**
Sacramento Metropolitan	544,968	16,217	44,900	434,000	1,040,085
Air Taxi[2]	4,386	N/A	N/A	N/A	4,386
Basin Total:	549,354	16,217	44,900	434,000	1,044,471

VENTURA COUNTY AIR BASIN					
Airport	**Aircraft**	**APUs**	**GSE**	**Vehicles[1]**	**Total**
Oxnard/Ventura County	1,788	N/A	N/A	3,122	4,910
Air Taxi[2]	2,370	N/A	N/A	N/A	2,370
Basin Total:	4,158	N/A	N/A	3,122	7,280

Source: EEA memorandum *Technical Support Document Errata* (Reference 18)

[1] Excluded from the control strategy

[2] Air Taxi refers to the total air taxi emissions from all airports in the basin.

FIGURE 2-7: SUMMARY OF 1994 TSD BASELINE AND FORECAST GROWTH RATES

BASIN	Inventory Period	Compound Annual Growth Rate From Baseline - Commercial -
South Coast	1990 1990 - 2000 1990 - 2005 1990 - 2010	Baseline 3.44% 3.20% 3.00%
Ventura	1990 1990 - 2000 2000 - 2005	Baseline 1.500% 1.324%
Sacramento	1990 1990 - 1999 1999 - 2000 2000 - 2005	Baseline 2.16% 2.08% 1.93%

Source: EEA memorandum *South Coast Aviation Growth Rates* (Reference 17)

2.2.2.1 Aircraft

The total emissions from air carrier and air taxi aircraft for each airport were calculated following the same procedures as the baseline inventory, as discussed in Section 2.2.1. Summary tables of the baseline and forecast emissions included in the 1994 TSD appear in Figures 2-8 and 2-9.

2.2.2.2 Auxiliary Power Units

The calculation process for forecasting APU emissions was the same as that used to calculate the baseline inventory, as discussed in Section 2.2.1. Summary tables of the baseline and forecast emissions included in the 1994 TSD appear in Figures 2-10 and 2-11.

2.2.2.3 Ground Support Equipment

The calculation process for forecasting GSE emissions was the same as that used to calculate the baseline inventory, as discussed in Section 2.2.1. Summary tables of the baseline and forecast emissions included in the 1994 TSD appear in Figures 2-12 and 2-13.

2.2.3 Noise Regulation Emissions Benefit Calculation

On January 1, 2000 all aircraft with Stage II engines, involving approximately 2,000 aircraft from the 1990 U.S. fleet, will be prevented from operating at most airports nationwide as a result of the Airport Noise and Capacity Act of 1990 (ANCA), passed to reduce noise disturbance from jet aircraft. Stage II engines, which include all engines on early B-727s and B-737s, exceed ANCA noise standards. Stage III engines are quieter and, generally, although not exclusively, are newer and emit smaller amounts of pollutants. This regulation will result in the early retirement of older, generally high emission aircraft, which will be replaced by newer aircraft that have improved environmental performance. The issue of emission benefits created by ANCA is discussed in the 1994 TSD (Reference 7).

FIGURE 2-8: SUMMARY OF 1994 TSD AIRCRAFT EMISSIONS FORECAST HC (lb/yr)

SOUTH COAST AIR BASIN				
Airport	**1990**	**2000**	**2005**	**2010**
Burbank	41,761	98,613	98,406	90,714
John Wayne	60,704	159,523	159,964	148,596
Long Beach	27,312	51,089	49,971	45,206
Los Angeles Intl	4,529,620	3,677,603	3,340,773	3,091,899
Ontario Intl	224,544	252,571	235,063	209,713
Air Taxi[1]	195,115	273,649	312,916	352,183
Basin Total:	5,079,056	4,513,048	4,197,093	3,938,311

SACRAMENTO AIR BASIN				
Airport	**1990**	**1999**	**2000**	**2005**
Sacramento Metropolitan	107,818	127,042	116,118	112,027
Air Taxi[1]	37,306	48,928	50,425	58,624
Basin Total:	145,124	175,970	166,543	170,651

VENTURA COUNTY AIR BASIN			
Airport	**1990**	**2000**	**2005**
Oxnard/Ventura County	7,030	5,756	5,714
Air Taxi[1]	20,160	24,864	28,896
Basin Total:	27,190	30,620	34,610

Source: EEA memorandum *South Coast Aviation Growth Rates* (Reference 17)

[1] Air Taxi refers to the total air taxi emissions from all airports in the basin.

FIGURE 2-9: SUMMARY OF 1994 TSD AIRCRAFT EMISSIONS FORECAST
NO_x (lb/yr)

SOUTH COAST AIR BASIN				
Airport	**1990**	**2000**	**2005**	**2010**
Burbank	367,430	685,597	791,641	901,134
John Wayne	610,200	929,412	1,073,063	1,221,272
Long Beach	247,353	340,993	393,919	449,123
Los Angeles Intl	6,896,490	10,456,337	11,985,833	13,484,489
Ontario Intl	932,005	1,525,062	1,756,549	1,991,870
Air Taxi[1]	22,938	32,170	36,786	41,402
Basin Total:	9,076,416	13,969,571	16,037,791	18,089,290

SACRAMENTO AIR BASIN				
Airport	**1990**	**1999**	**2000**	**2005**
Sacramento Metropolitan	544,968	815,966	839,822	929,502
Air Taxi[1]	4,386	5,752	5,928	6,892
Basin Total:	549,354	821,718	845,750	936,394

VENTURA COUNTY AIR BASIN			
Airport	**1990**	**2000**	**2005**
Oxnard/Ventura County	1,788	1,938	2,089
Air Taxi[1]	2,370	2,923	3,397
Basin Total:	4,158	4,861	5,486

Source: EEA memorandum *South Coast Aviation Growth Rates* (Reference 17)

[1] Air Taxi refers to the total air taxi emissions from all airports in the basin.

FIGURE 2-10: SUMMARY OF 1994 TSD APU EMISSIONS FORECAST HC (lb/yr)

SOUTH COAST AIR BASIN				
Airport	**1990**	**2000**	**2005**	**2010**
Burbank	1,207	1,649	1,866	2,082
John Wayne	759	1,274	1,441	1,607
Long Beach	692	894	1,012	1,131
Los Angeles Intl	5,507	6,496	7,277	7,732
Ontario Intl	2,289	2,697	3,044	2,259
Basin Total:	10,454	13,010	14,640	14,811

SACRAMENTO AIR BASIN				
Airport	**1990**	**1999**	**2000**	**2005**
Sacramento Metropolitan	1,064	1,227	1,233	513

Source: EEA memorandum *South Coast Aviation Growth Rates* (Reference 17)

FIGURE 2-11: SUMMARY OF 1994 TSD APU EMISSIONS FORECAST
NO_x (lb/yr)

SOUTH COAST AIR BASIN				
Airport	**1990**	**2000**	**2005**	**2010**
Burbank	19,783	32,491	37,546	42,623
John Wayne	21,576	25,957	29,987	34,042
Long Beach	8,092	14,155	16,379	18,601
Los Angeles Intl	131,403	226,599	260,513	282,984
Ontario Intl	31,484	58,265	67,250	50,824
Basin Total:	212,338	357,467	411,675	429,074

SACRAMENTO AIR BASIN				
Airport	**1990**	**1999**	**2000**	**2005**
Sacramento Metropolitan	16,217	23,456	24,088	10,406

Source: EEA memorandum *South Coast Aviation Growth Rates* (Reference 17)

FIGURE 2-12: SUMMARY OF 1994 TSD GSE EMISSIONS FORECAST
HC (lb/yr)

SOUTH COAST AIR BASIN				
Airport	**1990**	**2000**	**2005**	**2010**
Burbank	12,865	16,783	21,050	22,689
John Wayne	15,194	22,293	24,660	26,988
Long Beach	6,820	8,688	9,173	11,636
Los Angeles Intl	206,738	298,557	318,646	355,414
Ontario Intl	19,229	25,942	29,544	32,301
Basin Total:	260,846	372,263	403,073	449,028

SACRAMENTO AIR BASIN				
Airport	**1990**	**1999**	**2000**	**2005**
Sacramento Metro-politan	15,618	20,625	21,050	22,293

Source: EEA memorandum *South Coast Aviation Growth Rates* (Reference 17)

FIGURE 2-13: SUMMARY OF 1994 TSD GSE EMISSIONS FORECAST
NO_X (lb/yr)

SOUTH COAST AIR BASIN				
Airport	**1990**	**2000**	**2005**	**2010**
Burbank	36,158	48,229	57,988	61,250
John Wayne	43,334	60,043	69,610	73,174
Long Beach	20,723	25,111	25,580	33,315
Los Angeles Intl	563,948	811,916	865,707	967,351
Ontario Intl	50,467	68,797	79,575	88,052
Basin Total:	714,630	1,014,096	1,098,460	1,223,142

SACRAMENTO AIR BASIN				
Airport	**1990**	**1999**	**2000**	**2005**
Sacramento Metropolitan	44,900	57,564	57,988	60,043

Source: EEA memorandum *South Coast Aviation Growth Rates* (Reference 17)

2.2.4 <u>Emission Limits</u>

2.2.4.1 <u>Emission Caps</u>

EPA intended to establish emission reduction requirements for commercial aircraft and related mobile sources that were generally consistent with the emission cap requirements for stationary sources in the control areas. This would have been accomplished through a series of uniform annual reductions of baseline emissions of each pollutant. A series of example caps was calculated to illustrate the impact of such a strategy on commercial aircraft operations.

2.2.4.2 <u>Regulatory Alternatives</u>

There were two ways considered in administering and enforcing the series of emission caps as described above: (1) an absolute emission basis or (2) an emissions rate basis. The advantages and disadvantages of both alternatives were discussed in the preamble to the proposed control program and the 1994 TSD. EPA concluded that the most appropriate strategy would be an emission rate-based emission reduction program for commercial aircraft operators.

2.2.4.3 <u>Environmental Performance Target</u>

In the proposal, each commercial airline would be required to achieve an industry-wide series of declining emission rate targets. The recommended emission rate targets were expressed as pounds of pollutant emitted per passenger or unit of cargo, although alternative measures such as emissions per LTO and emissions per ton-mile were considered. The proposed form of the target for each pollutant was pounds of emissions per passenger equivalent unit (PEU). PEUs would reflect both the actual number of passengers carried and the actual tonnage of cargo transported on commercial airlines. Figure 2-14 summarizes the emission performance targets calculated in the 1994 TSD for the South Coast Air Basin based on emissions caps and the forecast PEU. The emission caps and PEUs were adjusted to reflect the ozone season compliance period. Whether an airline had met the program requirements for a given ozone season would be

FIGURE 2-14 1994 TSD EMISSION PERFORMANCE TARGETS FOR COMMERCIAL AIRCRAFT
SOUTH COAST AIR BASIN

HC						
	Lower Range			Higher Range		
Control Period	Lower Emission Cap (lbs/year)	Activity Forecast* (PEU/year)	Performance Target (lbs/PEU)	Higher Emissions Cap (lbs/year)	Activity Forecast* (PEU/year)	Performance Target (lbs/PEU)
1990	5,350,356	61,831,080	0.087	5,350,356	61,831,080	0.087
2001	5,136,342	89,206,791	0.058	4,868,824	89,206,791	0.055
2002	4,922,328	91,695,492	0.056	4,387,292	91,695,492	0.048
2003	4,708,314	94,184,193	0.050	3,905,760	94,184,193	0.042
2004	4,494,299	96,672,894	0.047	3,424,228	96,672,894	0.035
2005	4,280,285	99,177,052	0.043	2,942,696	99,177,052	0.030

NO_x						
	Lower Range			Higher Range		
Control Period	Lower Emission Cap (lbs/year)	Activity Forecast* (PEU/year)	Performance Target (lbs/PEU)	Higher Emissions Cap (lbs/year)	Activity Forecast* (PEU/year)	Performance Target (lbs/PEU)
1990	10,003,385	61,831,080	0.162	10,003,385	61,831,080	0.162
2001	9,403,182	89,206,791	0.105	9,103,080	89,206,791	0.102
2002	8,802,979	91,695,492	0.096	8,202,776	91,695,492	0.089
2003	8,202,776	94,184,193	0.087	7,302,471	94,184,193	0.078
2004	7,602,573	96,672,894	0.079	6,402,166	96,672,894	0.066
2005	7,002,370	99,177,052	0.071	5,501,862	99,177,052	0.056

Source: EEA memorandum *South Coast Aviation Growth Rates* (Reference 17)
* 1990 data actual

determined by comparing an environmental performance factor against EPA's published pounds-per-PEU target for that ozone season.

2.2.4.4 Emissions Fee

In the proposal, airlines that achieved an ozone season's target would not be required to take any additional action. Any airline that exceeded the target in any ozone season, however, would pay an emissions fee proportional to the resultant excess emissions. The fee's purpose was to induce airlines to undertake appropriate emissions reduction measures, and not to collect substantial punitive damages. A fee of $10,000/ton of pollutant was considered for initial use in the commercial aviation control strategy.

2.2.5 Emission Mitigation

2.2.5.1 Potential Mitigation Measures

There are various measures airlines can take to improve the environmental performance of their operations. The proposed control strategy was designed to allow individual carriers to achieve the emission performance targets in the manner best suited to their own business strategy, fleet makeup, and corporate priorities. Potential mitigation measures addressing aircraft, APUs, and GSE and how they effect emissions were discussed in the 1994 TSD. Potential mitigation measures discussed in the proposed rule included single/reduced engine taxiing, reducing airport congestion, modernizing and managing the fleet, providing central ground power and air, and converting GSE to alternative fuels.

2.2.5.2 Mitigation Strategies

To evaluate the effect on emissions per PEU of applying the mitigation measures, several scenarios were analyzed for the 1994 TSD where different combinations of measures were applied. Analysis was presented in the 1994 TSD for the South Coast Air Basin only. The combinations of measures presented did not exhaust the list of potential actions that airlines could take to reduce their emissions per PEU, but served to indicate the degree of control that would be needed. From this analysis it was seen that even the most stringent HC target could be easily met, but that the reduction of NO_x was more challenging.

2.3 INTERIM FINAL RULE (IFR) ANALYSIS

This section discusses the commercial aviation aircraft, APU, and GSE emission inventories, costs, and benefits developed in support of this interim final rulemaking. The current interim final rule drops the bubble approach proposed in the 1994 TSD (Reference 7) that included aircraft. In its place are command and control regulations directed at auxiliary power units and ground support equipment that minimize auxiliary power unit operations and require zero-emitting ground support equipment (e.g., electrification) to the maximum extent feasible. Ground support equipment certified for on-road use for which electrification or another zero-emitting technology is not possible would be subject to Inherently Low Emission Vehicle (ILEV) clean fleet requirements.

The IFR, like the original proposal, targets aviation activity occurring in the control areas during the applicable ozone seasons:

South Coast -- March through October
Ventura -- April through October
Sacramento -- May through October

The ozone season control strategy was selected because ozone is a seasonal pollution concern, and thus there is no need to require mitigation measures for emissions of ozone precursors in other months. From a practical standpoint, however, most of the measures that will be implemented in response to the IFR will affect emissions throughout the year, since such measures involve modifications to airport infrastructures or aviation support equipment.

This analysis includes aircraft operations that are operated by a person who has an FAA certificate to operate pursuant to 14 C.F.R. Parts 121, 125, 127, 129, or 135 of this title and offers its services, for compensation or hire, engages in the carriage by commercial aircraft in air commerce of persons or property, and is responsible for the operations of a particular fleet of commercial aircraft that routinely flies into and out of a commercial airport of the FIP areas.

2.3.1 Aircraft

Emission inventories of aircraft main engine emissions were calculated for the proposed rule. Aircraft main engine emissions are not included in the interim final rule and, therefore, these inventories were not updated and costs and benefits were not developed. FAA comments on aviation emission control measures, which address aircraft emissions in part, appear in Appendix 2-11.

2.3.2 Auxiliary Power Units

An auxiliary power unit (APU), which is a component of a large aircraft, is essentially a small turbine engine. An APU generates electricity and compressed air to operate the aircraft's instruments, lights, ventilation, and other equipment and for starting the aircraft main engines. If a ground-based power or air source is unavailable, the APU may be operated for extended periods when the aircraft is on the ground with its engines shut down. These engines burn jet fuel and create exhaust emissions like larger engines. There are different models and series of APUs to meet the needs of various civil aircraft. APUs are not common on smaller civil aircraft.

APUs are used on a routine basis throughout much of the time when an aircraft is on the ground. Operating practices largely are determined by individual airlines and vary considerably among aircraft types and airlines. Some airlines start the APU when the aircraft is on approach and keep it on during the entire taxi-in phase as a precaution to insure its availability if needed for engine restart. Some airlines only operate their APUs on taxi-in if they are practicing single/reduced engine taxiing. Again, this is to insure its availability if the main engine(s) shuts down and must be restarted. Some airlines do not operate APUs during the taxi-in phase at all or only for particular aircraft types. Once docked the APU is used to provide electric power and ventilation.

On departure, the critical service provided by the APU is main engine start. This requires a large volume of air to initiate rotation of the turbine and mass flow through the combustor. For routine operation this takes less than one minute. Once the main engine(s) are started they provide the electric power and ventilation to the aircraft. Again, some airlines prefer to keep the APU running during taxi-out as a back-up.

Prior to main engine start the cockpit crew goes through their departure checklist and readies their flight plan. During this time, course settings and communication frequencies are programmed into the on-board avionics. If the aircraft electrical system is interrupted while the avionics are being programmed, some of the data may be lost. For this reason, most airlines prefer to have the APU running to provide the electric power for the aircraft rather than relying on electric power provided from a ground-based system that must be disconnected, possibly interrupting or perturbing the on-board power. An APU also is operated during taxi out for passenger comfort if the aircraft must park away from the gate due to a delayed departure.

The balance of Section 2.3.2 describes the baseline APU emissions inventory, an APU emissions forecast, and a recommended control strategy. The section ends with a discussion of the cost of mitigating APU emissions.

2.3.2.1 1990 APU Emissions Inventory

Any emissions reduction program fundamentally requires a starting point from which progress towards attainment can be tracked and verified. The Clean Air Act requires EPA to establish emission reduction targets from 1990 emission levels. In the 1994 TSD (Reference 7), commercial aviation activity, which is related to emissions, was reviewed over a several-year period to consider whether 1990 is a suitable baseline period. 1990 appears representative of typical aviation activity during this period, with no effects that would make it appear unrepresentative identified. Baseline emissions calculations therefore were made for 1990 APU operations as discussed below.

Calculation Methodology

The methodology for calculating emissions from APUs (which is adapted from U.S. EPA's *Procedures for Emission Inventory Preparation* (Reference 34)) is done in two steps. The first step of the process calculates the emissions from APUs for each aircraft type. The second step calculates the total emissions from APUs for all aircraft. A summary of total HC and NO_x APU baseline emissions by area and airport is provided in Figure 2-15. Appendix 2-1 contains detailed APU emissions data by aircraft at each airport.

APU Emissions for Each Aircraft Type

This equation calculates the emissions from APUs for each aircraft type based on APU time in mode, fuel flow, and the emission indices for the specific APU.

$$E_{ij} = (TIM)_{avg} \times (FF_j/1000) \times (EI_{ij})$$

Where:
- E_{ij} - total APU emission of pollutant i, in pounds, produced by the APU model installed on aircraft type j for one LTO cycle
- TIM_{avg} - weighted average operating time per LTO cycle (time in mode), in minutes
- FF_j - fuel flow, in pounds per minute, for each APU used on aircraft type j
- EI_{ij} - emission index for pollutant i, in pounds of pollutant per one thousand pounds of fuel, for each APU used on aircraft type j
- i - pollutant type (HC, NO_x)
- j - aircraft type (e.g., B-737, MD-11)

Total APU Emissions for All Aircraft

This equation calculates the total APU emissions for all aircraft in the given inventory.

$$E_{Ti} = \Sigma (E_{ij}) \times (LTO_j)$$

Where:
- E_{Ti} - total APU emissions of pollutant i, in pounds, produced by all aircraft operating in the inventory area
- LTO_j - number of landing and takeoff cycles by aircraft j for the inventory time period

FIGURE 2-15: SUMMARY OF APU EMISSIONS - 1990
(lb/yr)

SOUTH COAST AIR BASIN		
Airport	**HC**	**NO_x**
Burbank	1,781	29,200
John Wayne	1,270	36,118
Long Beach	2,283	26,700
Los Angeles Intl	39,658	959,438
Ontario Intl	8,819	121,319
Basin Total:	53,811	1,172,775

SACRAMENTO AIR BASIN		
Airport	**HC**	**NO_x**
Sacramento Metropolitan	1,064	16,217

NOTE: There are no APU emissions from the Ventura Air Basin since the smaller aircraft that operate there do not use APUs.

Data Sources

The data needed for calculating emissions from APUs include air carriers operating in the FIP areas, aircraft type and model, APU model, APU emission factors, aircraft LTOs, and APU operating time.

- **Air Carriers** - Certificated route air carriers, as designated by the FAA and included in FAA *Airport Activity Statistics of Certificated Route Air Carriers (AAS)* (Reference 14), were included in this inventory. Air taxis and smaller air carriers are excluded from the APU inventory, since these aircraft do not require APUs. As a result, Oxnard/Ventura County Airport does not include APU emissions since all carriers that operate at the airport are air taxis or small air carriers.

- **Aircraft** - The aircraft fleet operated by each air carrier came from Exxon's *Turbine-Engined Fleets of the World's Airlines: Survey 1991* (Reference 8), which lists the full operating fleet for all airlines. This data was used to define aircraft for emissions calculations.

- **APU Model** - The APU models that are installed on the aircraft must be determined to select the emission factors used in developing this emissions inventory. The two sources of information used for this inventory are:

  - Federal Express Aviation Services, Inc.'s *Federal Express Fleet Guide* (Reference 9), and
  - Garrett Turbine Engine Company's *Reference Guide - Auxiliary Power Systems* (Reference 10).

- **Aircraft LTOs** - Aircraft LTOs by airline and aircraft type were necessary to estimate which aircraft/APU combinations to use in emission calculations. Data Sources used in this analysis were discussed extensively in the 1994 TSD (Reference 7).

- **APU Time in Mode** - APU operating time must be known to calculate emissions. For the proposed rule, EEA estimated APU operating times based on current facilities at each airport. These estimates resulted in significantly lower operating times than those reported by the ATA in its comments on the proposed rule. For the present analysis APU times in mode were obtained from the *Comments of the Air Transport Association on EPA's Proposed Federal Implementation Plan Measures for Commercial Aviation* (Reference 2) for all airports except Sacramento Metropolitan Airport. For Sacramento Metropolitan Airport, no primary sources of data were identified that gave APU operating time per year or per LTO. Operating time was estimated using the same methodology used for the proposal, which resulted in an average 25.7 minutes per LTO (see 1994 TSD (Reference 7)). A summary of the APU times in mode used to develop the emissions inventory and evaluate the costs and benefits of the interim final rule is provided in Figure 2-16.

FIGURE 2-16: SUMMARY OF APU TIMES IN MODE - 1990 (min/LTO)

Airport	Time in Mode
South Coast Air Basin	
Burbank	44.28
John Wayne	33.48
Long Beach	98.99
Los Angeles Intl	105.34
Ontario Intl	115.62
Sacramento Air Basin	
Sacramento Metropolitan	25.70

Source: South Coast Air Basin - *Comments of the Air Transport Association on EPA's Proposed Federal Implementation Plan Measures for Commercial Aviation* (Reference 2).
Sacramento Air Basin - 1994 TSD (Reference 7)

2.3.2.2 Forecast of APU Emissions

Uncontrolled emissions forecasts were calculated to evaluate the impact of the IFR emissions control strategy applied to aviation sources. This section presents the forecast inventories for APU emissions and the assumptions behind them. Forecasts were developed for 2000, 2005, and 2010 for the South Coast Air Basin and 1999, 2000, and

2005 for the Sacramento Air Basin. Growth rates for aircraft activity are discussed below as well as the methodology used in forecasting emissions from APUs.

California Airports Growth Rates

The principal factor in forecasting emissions is the level of future aircraft activity. Several sources for growth rates were examined and compared in the 1994 TSD (Reference 7). In the 1994 TSD (Reference 7), growth rates for aviation activity developed by the South Coast Association of Governments (SCAG) were used for all commercial aviation in the South Coast Air Basin for this analysis. These growth factors are:

1990 LTOs * 1.403 = 2000 LTOs (or an annual growth of 3.440%),
1990 LTOs * 1.604 = 2005 LTOs (or an annual growth of 3.200%), and
1990 LTOs * 1.805 = 2010 LTOs (or an annual growth of 3.000%).

Airport forecasted growth rates were used in the Sacramento Air Basin, which also were used for the proposed rule. Figure 2-17 summarizes the growth rates used to develop the growth factors to forecast the airport activity. Figure 2-18 summarizes the baseline and forecast LTOs. These values formed the basis of the forecast APU emission inventories.

Calculation Methodology

The calculation methodology for forecasting APU emissions is the same as that used to calculate the baseline inventory discussed in Section 2.3.2.1. See the 1994 TSD (Reference 7) for detailed information on the calculation process. Many of the sources of inputs also are the same as those used in the baseline, with a few exceptions, as discussed below. A summary of APU emissions for the baseline and each forecast year by area and airport is provided for HC and NO_x in Figures 2-19 and 2-20, respectively. Appendix 2-2 contains detailed APU emissions forecasts by aircraft at each airport.

FIGURE 2-17: SUMMARY OF BASELINE AND FORECAST GROWTH RATES

BASIN	Inventory Period	Compound Annual Growth Rate From Baseline - Commercial -
South Coast	1990 1990 - 2000 1990 - 2005 1990 - 2010	Baseline 3.44%[1] 3.20%[1] 3.00%[1]
Sacramento	1990 1990 - 1999 1999 - 2000 2000 - 2005	Baseline 2.16%[2] 2.08%[2] 1.93%[2]

NOTE: Data is unchanged from that used for the proposed regulation

1 Southern California Association of Governments

2 Sacramento Department of Airports

FIGURE 2-18: BASELINE AND FORECAST LTOs

SOUTH COAST AIR BASIN					
Airport	**Aircraft Class**[1]	**1990**	**2000**	**2005**	**2010**
Burbank	c1	26,129	31,882	36,457	41,032
	c2	0	4,764	5,448	6,131
	c4	4,388	6,154	7,037	7,920
	TOTAL	30,517	42,800	48,942	55,083
Long Beach	c1	13,364	18,743	21,433	24,122
	c2	148	208	237	267
	c4	1,076	1,509	1,726	1,942
	TOTAL	14,588	20,460	23,396	26,331
Los Angeles Intl (Domestic Carriers)	c1	134,475	153,535	175,566	197,598
	c2	27,926	58,860	67,306	75,752
	c3	35,561	65,245	74,608	83,970
	c4	18,354	25,741	29,435	33,129
	TOTAL	216,316	303,381	346,915	390,449
Los Angeles Intl (Foreign Carri-ers)	c1	9,988	11,100	12,694	14,286
	c2	1,975	3,464	3,962	4,457
	c3	12,301	19,466	22,257	25,054
	TOTAL	24,264	34,030	38,913	43,797
Ontario Intl	c1	37,737	49,877	57,034	64,191
	c2	4,219	7,324	8,375	9,426
	c3	1,271	3,425	3,916	4,407
	c4	2,590	3,632	4,154	4,675
	TOTAL	45,817	64,258	73,479	82,700
John Wayne	c1	25,950	36,395	41,617	46,840
	c2	4,567	6,405	7,324	8,243
	c4	6,907	9,687	11,077	12,467
	TOTAL	37,424	52,487	60,018	67,550

FIGURE 2-18: BASELINE AND FORECAST LTOs
(Continued)

SOUTH COAST AIR BASIN (Continued)					
Airport	**Aircraft Class[1]**	**1990**	**2000**	**2005**	**2010**
Basin Total	c1	247,643	301,532	344,801	388,069
	c2	38,835	81,025	92,652	104,276
	c3	49,133	88,136	100,781	113,431
	c4	33,315	46,723	53,429	60,133
	TOTAL	368,926	517,416	591,663	665,910

SACRAMENTO AIR BASIN					
Airport	**Aircraft Class[1]**	**1990**	**1999**	**2000**	**2005**
Sacramento Metropolitan	c1	25,907	27,716	27,934	29,941
	c2	78	3,779	3,991	4,673
	c4	13,737	16,650	16,877	18,299
	TOTAL	39,722	48,145	48,802	52,913

NOTE: Data is unchanged from that used for the proposed regulation.

[1] Aircraft Classes:

- c1 - Jet aircraft with a range less than 3,000 nautical miles and less than 175 seats
- c2 - Jet aircraft with a range over 3,000 and less than 5,000 nautical miles and over 175 seats
- c3 - Long range widebody aircraft with a range over 5,000 nautical miles
- c4 - All smaller aircraft (i.e., turboprop, business jets, and piston aircraft)

FIGURE 2-19: SUMMARY OF APU EMISSIONS FORECAST
HC (lb/yr)

SOUTH COAST AIR BASIN				
Airport	**1990**	**2000**	**2005**	**2010**
Burbank	1,781	2,434	2,753	3,073
John Wayne	1,270	2,132	2,412	2,691
Long Beach	2,283	2,950	3,340	3,731
Los Angeles Intl	39,658	43,582	48,805	53,941
Ontario Intl	8,819	10,393	11,728	13,060
Basin Total:	53,811	61,491	69,038	76,496

SACRAMENTO AIR BASIN				
Airport	**1990**	**1999**	**2000**	**2005**
Sacramento Metropolitan	1,064	1,227	1,233	513

FIGURE 2-20: SUMMARY OF APU EMISSIONS FORECAST
NO_x (lb/yr)

SOUTH COAST AIR BASIN				
Airport	**1990**	**2000**	**2005**	**2010**
Burbank	29,200	47,957	55,418	62,911
John Wayne	36,118	43,451	50,199	56,986
Long Beach	26,700	46,708	54,046	61,378
Los Angeles Intl	959,438	1,520,376	1,747,259	1,974,141
Ontario Intl	121,319	224,553	259,135	293,811
Basin Total:	1,172,775	1,883,045	2,166,057	2,449,227

SACRAMENTO AIR BASIN				
Airport	**1990**	**1999**	**2000**	**2005**
Sacramento Metropolitan	16,217	23,456	24,088	10,406

Data Sources

The data needed to forecast emissions from APUs are the same as needed for the inventory: aircraft, APU model, APU emission factors, aircraft LTOs, and APU time in mode. Although the input variables are the same as the baseline inventory, some inputs change to reflect future operations. The two key variables that change over time are aircraft fleet mix and LTOs. Other variables (APU model, emission factors, and time in mode) used in the forecast are the same as in the baseline inventory.

- **Aircraft** - In estimating future APU emissions a critical element is the aircraft fleet forecast, which determines the types of aircraft that will comprise future activity. Aircraft activity used to calculate APU emissions is unchanged from that used for the proposed regulation. For a detailed discussion of forecasting the aircraft fleet see EEA memorandum *Commercial Aviation Aircraft Forecast Methodology* (Reference 19), which is in the docket for this rulemaking.

- **Aircraft LTOs** - The aircraft in the forecast fleet were then classified into four general categories based on size and seating capacity. The classifications were necessary to ascertain what subsets of aircraft could be expected to operate at a given airport, and what percentage of the total commercial LTOs would be comprised by each class. Again, this data is unchanged from the proposed regulation.

2.3.2.3 Mitigation of APU Emissions

The IFR intends to minimize the use of APUs, by requiring fixed ground electric power and preconditioned air (PCA) to provide services to the aircraft instead of the currently used APUs.

The objective of the IFR is to minimize APU operation without interfering with the safe operation of the aircraft. Since power and preconditioned air can easily be provided by electrically driven ground based systems, the time the aircraft is parked offers the best opportunity for reducing APU use. APU use while the aircraft is underway or parked away from the normal docking area due to delay or maintenance problems should remain at the discretion of the pilot in command. The pilot in command is responsible for the safety of the passengers and the safe operation of the aircraft, and his or her authority to meet these responsibilities should not be limited.

On taxi-in the APU is not needed once the aircraft has been connected to a ground power system. This is done by plugging a cable into an electrical connector on the aircraft and commonly is done as soon as the aircraft comes to a stop. EEA believes that this can be done quickly along with other arrival preparations by the ground crew, such as choking the wheels and opening the lower baggage compartments, and recommends a maximum of 30 seconds of APU operation after the aircraft has come to a full stop. American Airlines proposed limiting APU operation following aircraft arrival at its docking location to 30 seconds in its November 7, 1994 proposal (Reference 5).

EEA understands from conversations with airline pilots and other airline representatives that on departure the essential preparations and main engine start can be accomplished in three to five minutes. (Most air carriers do not start their main engines until they have been pushed back from the gate. Since this takes less than one minute, the time of main engine start has only a small effect on the minimum time needed to operate the APU on departure.) On this basis EEA recommends setting a maximum APU operating time of five minutes for the departure phase of the LTO cycle. This results in a maximum essential APU operating time of 5.5 minutes while the aircraft is docked.

In addition to the time the aircraft is docked at a gate for passenger loading and unloading, aircraft also can be docked at remote gates or hardstand areas for cargo loading and unloading and for maintenance. For these locations the needs for APU operation are similar, except that passengers typically are not aboard the aircraft in these locations and thus the ventilation needs for passenger comfort do not exist. EEA believes that the 5.5 minute maximum APU operating time is appropriate for aircraft docked at these locations as well.

Effective January 1, 1993, Zurich Airport in Zurich, Switzerland, implemented an APU operating restriction through a change in the airport's operating policy. This regulation requires that all aircraft must be attached to a ground-based source of electricity as soon as the aircraft is docked. PCA is available at all gates and is provided if requested by the pilot. While the regulation does not set a firm limit on APU operating time the result of the regulation has been to limit APU operation to 5 minutes while at the gate, according to the director of the airport's environmental office (Reference 21). This supports the feasibility of EEA's recommended 5.5 minute maximum APU operating time.

In considering the time frame in which APU operation limitations could be implemented, three scenarios were identified with regard to the current ground power and PCA status of aircraft docking locations:

(1) aircraft docking locations at permanent airport terminals that have fixed ground power and PCA;

(2) aircraft docking locations at permanent airport terminals that do not have fixed ground power, or have fixed ground power but not PCA; and

(3) all other aircraft docking locations including remote gates and maintenance positions that may or may not have fixed ground power.

In the first case, gates that currently have fixed ground power and PCA would require no capital modifications. Airlines could begin procedures to minimize APU usage at these gates and begin reducing emissions as soon as new operating procedures and practices were established with the cockpit crews and ground support personnel. EEA believes this could be initiated by the first day of the 1997 ozone season since some air carriers already follow similar procedures at gates with ground power and PCA available.

In the second case, gates that currently do not have fixed ground power, or have fixed ground power but not PCA, would require installation of the needed system(s). For existing passenger loading gates without 400 Hz electric power, it was assumed that a power supply system would be added at each gate. The system would be sized to meet the requirements of a local frequency converter for the aircraft while parked, the operation of a local PCA unit, and for recharging GSE. Only minimal requirements for modifying the existing terminal electricity distribution system were assumed. It also was assumed that one back-up mobile electric frequency converter unit per 5 gates would be added to supply power if the fixed frequency converter installation is out of service. For existing passenger loading gates without PCA units, it was assumed that a local PCA unit sized to supply air for a single aircraft would be added at each gate. It also was assumed that one back-up mobile electric PCA unit per 5 gates would be added to supply PCA if the fixed PCA unit is out of service. A reasonable amount of time would be needed for designing funding and installing the needed system(s). Once installed, airlines could begin procedures to minimize APU usage at these gates and begin reducing emissions. Based on these considerations, EEA believes these modification could be completed and the new procedures implemented by the first day of the 1999 ozone season.

Finally, other aircraft parking locations remote from the terminal rarely have fixed ground power or PCA according to representatives of the FIP area airports. These locations commonly are serviced by mobile gasoline or diesel generators. These locations would require the installation of fixed ground power. Where passengers may be present at one of these other aircraft parking locations, the installation of PCA units also would be required. Since passengers commonly are not on aircraft at overnight and maintenance parking locations it is unlikely that PCA units will be required. EEA does not have information on the number of remote docking locations and whether they presently have fixed power available. In evaluating the cost of a rule limiting APU operation, EEA assumed that the number of remote gates was equal to 20% of the number of gates at the terminal(s) (based on remote gates a percent of total gates at LAX (Reference 22)), that fixed power would be required at each location, and that passengers would not be present on the aircraft at these remote docking locations so that

PCA would not be required. It was assumed that a local frequency converter system would be added at each parking position, permanently installed and sized to meet the requirements of the aircraft while parked. A power supply system sized to meet the needs for recharging GSE also was assumed. It further was assumed that the installation cost to meet the new electrical needs at the remote gates is significant since it may be necessary to run new electric wiring over long distances and run new cable and conduit through existing concrete. Due to the additional installation costs and effort, EEA assumed it would take additional time to finance, engineer, and construct these facilities. Based on these considerations, EEA believes that requirements to minimize the use of APUs could be fully implemented at all aircraft docking locations at all airports in the FIP areas no later than the first day of the 2002 ozone season.

The following section summarizes the calculation methodology and data sources for forecasting annual APU emissions effected by the FIP requirements. Then the capital cost and cash flow due to the APU operating limits are discussed. It was assumed that none of the new APU requirements would be met until the required date.

Growth Rates

The principal factor in forecasting emissions is the level of future activity. For a detailed discussion of the growth rates used, see the APU forecast section (Section 2.3.2.2). These growth rates were used to forecast the activity for 2000, 2005, and 2010 (1999, 2000, and 2005 for Sacramento Metropolitan Airport) from the 1990 baseline. The annual activity at each airport was estimated by assuming that the LTOs increased linearly between the years for which data was available. For Sacramento Metropolitan Airport, it was assumed that the LTOs did not increase after 2005.

Operations Affected by the IFR

To calculate the annual APU emissions affected by the IFR requirements, the annual activity at each airport affected by the IFR requirements was estimated. As a first step, the total activity was allocated between fixed gates (affected by the 1997 and 1999 requirements) and remote gates. Since primary data on the number of LTOs occurring at remote gates was not available, all-cargo LTOs were assumed to occur at remote gates. No data on activity of all-cargo flights was provided by air carriers or ATA. All-cargo flight activity was estimated using FAA's *Airport Activity Statistics of Certificated Route Air Carriers* (Reference 14), supplemented with data provided by the United Parcel Service (Reference 13). For each airport, the percent of LTOs identified as all-cargo LTOs in FAA's report was applied to the airport's forecasted activity to estimate the number of all-cargo LTOs to be allocated to remote gates. The remaining number of LTOs at each airport was assumed to represent the activity occurring at fixed gates affected by the 1997 and 1999 requirements. Due to the lack of primary data, this methodology provides only a crude estimate of the emissions benefit at remote gates for the 2002 requirement. This methodology also is a conservative (low) estimate of the emissions benefit since LTOs do not account for all the maintenance and other activity at remote gates where APUs may be in use. The percentage of all-cargo LTOs assumed for each airport are listed below.

Airport	All-Cargo LTOs %
Burbank	0.81%
John Wayne	0%
Long Beach	3.65%
Los Angeles Intl	2.23%
Ontario Intl	7.92%
Sacramento Metro	3.48%

The second step of this process was to allocate the fixed gate activity between those occurring at gates affected by the 1997 requirement and the 1999 requirement. The annual activity at each airport affected by each of the requirements was assumed to be directly proportional to the percent of fixed gates affected by the 1997 and 1999 requirements.

Figure 2-21 provides information by airport on the number of gates (both fixed and remote), the current status of those gates (whether fixed ground power and preconditioned air currently are available), and the power and air requirements of those gates under the new regulation. Appendix 2-3 provides printouts for each airport listing the total annual LTOs and number of LTOs effected by the each of the three requirements.

Calculation Methodology - Annual APU Emissions Benefit

The APU emissions reduction benefit results from the reduced APU operating time due to use restrictions while at a docking location. This is determined by taking the difference between the unrestricted APU emissions and the emissions calculated after implementing operating limits. Fixed ground power and PCA units are essential for limiting APU use, however, these units are powered by electricity and are assumed to be zero-emission sources. The benefits are calculated on a per LTO basis for each airport and then multiplied by the level of activity to reflect the benefit in any given year for which LTOs have been forecast. Annual benefits are calculated even though the IFR only requires these restrictions during the ozone season. EEA has assumed that the necessary facilities and procedures will be used all year rather than only during the ozone season, once they are available.

Data Sources - Annual APU Emission Benefits

The data needed for calculating the annual APU emissions effected by the FIP requirements are the same as the APU forecast: aircraft, APU model, APU emission factors, aircraft LTOs, and APU time in mode. The sources of the inputs also are the same as in the APU forecast. See the APU forecast section (Section 2.3.2.2) for a detailed discussion of the inputs. For airports in the South Coast Air Basin, the emissions benefit was calculated as the difference between the emissions from the APU being run at the present average time per LTO provided by ATA and the emissions from the APU when limited to the allowed 5.5 minutes per LTO gate time plus the airport's FAA average taxi time from ATA's average time per LTO. The airport's FAA average taxi time is

FIGURE 2-21: AIRPORT GATE INFORMATION

Airport	No. of Gates	Current Gate Status[1]	Future Gate Requirements
Burbank	14 3[2]	- -	Power & PCA Power
John Wayne	14 3[2]	Power -	PCA Power
Long Beach	15 3[2]	- -	Power & PCA Power
Los Angeles Intl (Domestic Carriers)	33 60 19[2]	Power & PCA Power -	- PCA Power
Los Angeles Intl (Foreign Carriers)	12 2[2]	Power & PCA -	- Power
Ontario Intl	30 6[2]	- -	Power & PCA Power
Sacramento Metro	3 11 3[2]	Power & PCA - -	- Power & PCA Power

[1] Source: 1994 TSD (Reference 7)

[2] Refers to remote and maintenance gates. The number of remote and maintenance gates was estimated to be 20% of the total number of airport gates. It was assumed that these gates only would require fixed power.

added to the allowed 5.5 minutes per LTO at the gate since the ATA time includes operation during taxi, which is not restricted under the IFR regulations. ATA did not provide an average APU operating time per LTO for Sacramento Metro Airport. The APU operational time per LTO while at the gate was estimated using the same methodology as in the 1994 TSD (Reference 7). The emissions benefit for Sacramento Metro Airport was calculated as the difference between the emissions from the APU being run at the estimated average time per LTO and the emissions from the APU when limited to the allowed 5.5 minutes per LTO gate operation. The following lists the reduction of APU usage in minutes per LTO of APU operation after implementation of the rule.

Airport	ATA Average APU Time (min/LTO)	Allowed Gate Time (min/LTO)	FAA Average Taxi Time (min/LTO)	APU Operation Reduction (min/LTO)
Burbank	44.28	5.50	13.50	25.28
John Wayne	33.48	5.50	18.40	9.58
Long Beach	98.99	5.50	14.50	78.99
Los Angeles Intl	105.34	5.50	23.80	76.04
Ontario Intl	115.62	5.50	15.20	94.92
Sacramento Metro	25.70[1]	5.50	N/A[2]	20.20

[1] The Sacramento Metro average APU time was not provided by ATA. It is estimated as run time while at the gate using the same methodology as in the 1994 TSD (Reference 7). The estimated average APU time reduces to 10 minutes/LTO beginning in 2005 due to facility modifications, which already are planned.

[2] Not Applicable.

Figure 2-22 summarizes the APU emission benefit for the South Coast and Figure 2-23 the same information for Sacramento. Appendix 2-3 summarizes total annual APU emission benefits for each phase of the rule implementation for each airport. (The information in Appendix 2-3 was created for the Regulatory Impact Analysis (RIA) for the FIP. For more information on the data in this appendix, please see the RIA, published separately.)

**FIGURE 2-22: APU EMISSION BENEFIT
SOUTH COAST AIR BASIN**

Year	HC (lbs)	NO_x (lbs)
1997	11,936	395,809
1998	12,311	408,240
1999	42,376	1,128,352
2000	42,441	1,298,709
2001	43,660	1,335,986
2002	46,410	1,415,380
2003	47,670	1,453,795
2004	49,049	1,506,638
2005	49,774	1,563,358
2006	51,024	1,602,602
2007	52,273	1,641,838
2008	53,522	1,681,066
2009	54,771	1,720,315
2010	55,131	1,767,019

FIGURE 2-23: APU EMISSION BENEFIT SACRAMENTO AIR BASIN

Year	HC (lbs)	NO_x (lbs)
1997	191	2,941
1998	195	3,000
1999	890	17,166
2000	900	17,527
2001	915	17,822
2002	964	18,773
2003	980	19,078
2004	996	19,384
2005	230	4,675
2006	230	4,675
2007	230	4,675
2008	230	4,675
2009	230	4,675
2010	230	4,675

2.3.2.4 Cost of Mitigating APU Operation

This section discusses the calculation methodology and data sources for calculating the cost impact of the IFR rule restricting APU use. The cost impact of the rule is the difference between the fixed systems' costs (e.g., operating and maintenance (O&M) and capital) and the APU cost reduction (O&M only) due to use restrictions. Two aspects of the cost impact are highlighted here: capital outlay and cash flow. Capital outlay is simply the total requirement for capital in a given year without considering any benefits due to reduced O&M costs. Cash flow considers both capital outlay and O&M cost difference to see the effect on cash requirements during each year of the control period. Annual costs are calculated even though the IFR only requires APU use restrictions during the ozone season. EEA has assumed that the necessary facilities and procedures will be used all year rather than only during the ozone season, once they are available.

Calculation Methodology - APU O&M Cost

The following describes the APU O&M cost calculations. The cost of operating APUs affected by the regulatory requirements is calculated by multiplying the number of LTOs effected by the requirements in each year, times the APU operation per LTO, times the O&M cost per hour of operation.

$$C_{APU,Y} = LTO_Y \times U \times OMC_{APU}$$

Where:

$C_{APU,Y}$ - annual cost, in dollars per year, of APUs affected in year Y
LTO_Y - number of annual LTOs affected in year Y
U - APU usage in hours per LTO
OMC_{APU} - APU O&M cost in dollars per hour
Y - the year

Data Sources - APU O&M Cost

The data needed for calculating the annual cost of operating APUs affected by the FIP requirements are APU operating time, aircraft LTOs affected by the requirements, and APU operating and maintenance costs. The sources of APU operating time and aircraft LTOs also are the same as in the APU emission mitigation section (Section 2.3.2.3). See the discussion of the growth rates and operations effected by the IFR regarding identifying only those aircraft LTOs affected by each of the three requirements.

- **APU Usage (hours/LTO)** - For this cost analysis, the savings in APU operating times were calculated by subtracting from the total current APU usage the allowed APU usage time (5.5 minutes per LTO gate operation and (where applicable) the taxi time) after implementation of the regulation. The following lists the minutes per LTO and hours per LTO of APU operation:

Airport	APU Operation[1] (min/LTO)	(hrs/LTO)
Burbank	25.28	0.421
John Wayne	9.58	0.159
Long Beach	78.99	1.316
Los Angeles Intl	76.04	1.267
Ontario Intl	94.92	1.582
Sacramento Metro[2]	20.20	0.336

[1] Excludes the 5.5 min/LTO (.092 hrs/LTO) gate operation and (where applicable) the taxi time, which are allowed APU operations in the FIP.
[2] Reduces to 4.5 min/LTO (0.075 hrs/LTO) based on reduced total taxi time beginning in 2005 due to planned facility modifications as documented in airport references.

The APU operating and maintenance cost input has not been used in previous FIP calculations. The development of this cost is discussed in the following:

- **APU O&M Cost ($/hour)** - APU operating and maintenance (O&M) costs per hour were estimated from narrow body and wide body aircraft APU O&M costs weighted by the percentage of narrow or wide body LTOs at an airport. Narrow and wide body aircraft APU O&M costs were calculated using maintenance costs and fuel consumption data from ASSI's 1994 feasibility study of pre-conditioned air for Northwest Airlines at Logan International Airport, Boston, Massachusetts (Reference 6) (see Appendix 2-4). The maintenance costs used were $14.60/hour for narrow body aircraft, and $50.90/hour for wide body aircraft. The fuel consumption basis is 37 gallons/hour fuel for narrow body aircraft, and 50 gallons/hour fuel for wide body aircraft. A $0.65/gallon fuel cost was assumed. These inputs and the following equation were used to calculate O&M costs:

O&M Cost =	Maintenance Cost + (Fuel Consumption x Fuel Cost)	
Narrow Body O&M Cost =	$14.60 + (37gal x $0.65/gal) = $38.65	
Wide Body O&M Cost =	$50.90 + (50gal x $0.65/gal) = $83.40.	

These O&M costs were weighted based on the number of narrow and wide body LTOs at the airport. The number of narrow and wide body LTOs was estimated using the airport LTO data by aircraft class contained in the APU forecast discussion (see Section 2.3.2.2). The percent of narrow and wide body LTOs and resulting O&M costs calculated were:

	Percent of Airport's LTOs		
Airport	Narrow Body	Wide Body	O&M Cost
Burbank	100%	0%	$38.65
John Wayne	100%	0%	$38.65
Long Beach	100%	0%	$38.65
Los Angeles Intl	80%	20%	$47.60
Ontario Intl	97%	3%	$39.99
Sacramento Metro	100%	0%	$38.65

Calculation Methodology - Fixed Systems

The following describes the fixed system (both power and PCA) installation and O&M cost calculations. In a case where a fixed power or PCA system needs to be installed, the capital cost is calculated by multiplying the installation cost per gate for fixed power or PCA by the number of gates affected by the regulatory requirement:

$$IC_S - CC_S \times G$$

Where:

- IC_S - installation cost, in dollars, of gates affected by fixed system S
- CC_S - gate capital cost in dollars per gate of gates affected by fixed system S
- G - number of gates affected
- S - fixed system type, either ground power or preconditioned air

The annual cost of operating and maintaining a fixed power or PCA system is calculated by multiplying the monthly energy cost per gate for fixed power or PCA by 12 months and the number of gates affected by the regulatory requirement:

$$OMC_{S,Y} = EC_S \times M_Y \times G$$

Where:

- $OMC_{S,Y}$ - annual O&M cost, in dollars per year, of gates affected by fixed system S in year Y
- EC_S - energy cost, in dollars per month, for a gate with fixed system S
- M_Y - number of months, 12, in a year
- G - number of gates affected
- S - fixed system type, either ground power or preconditioned air
- Y - the year

For this analysis, it was assumed that all capital costs are fully realized during the year in which the regulatory requirement must be met. O&M costs are realized each year, also beginning in the year in which the regulatory requirement must be met.

Data Sources - Fixed Systems

The data needed for calculating the cost of fixed systems are number of gates, current gate status, gate requirements, the installation cost per gate for fixed ground power, the energy cost per gate for fixed ground power, the installation cost per gate for preconditioned air, and the energy cost per gate for preconditioned air. The sources of data for number of gates, current gate status, and gate requirements are provided in the emissions mitigation calculations (see Section 2.3.2.3) discussion of APU operations affected by the FIP requirements and Figure 2-21. Data sources of the remaining inputs are discussed below.

- **Power Cost per Gate (Installed Capital)** - An installed cost of $35,000 per gate for fixed ground power was reported in American Airline's *South Coast Airport Bubble Data Task Force Background Information: August 18-19, 1993* (Reference 3) (see Appendix 2-5). It was assumed that this cost would be applicable for fixed gates. The installed capital cost per gate for remote locations was assumed to be 3 times higher ($105,000 per gate) due to the locations' distance from the main terminal and the possible need to install the power lines beneath existing structures and/or paved surfaces. It is assumed that significant additional wiring is needed to meet the new electrical needs. An additional $5,000 per gate was added to the installation cost of both fixed and remote gates for a mobile unit to provide back-up service to fixed ground power systems based on the assumption that one mobile unit is required per five gates and the cost of an electric unit is $25,000. The total installation costs are $40,000 per gate and $110,000 per gate for fixed and remote gates, respectively.

- **Power Cost per Gate (Energy)** - The monthly energy (or O&M) cost of $430 per gate for fixed ground power was based on $0.043/kWhr and the assumption that each gate would have an electricity demand of 10,000 kWhr/month. This was based on a study of fixed 400Hz power for National Airport (Reference 12) (see Appendix 2-6). The energy cost was assumed to be applicable for both fixed gates and remote locations.

- **PCA Cost per Gate (Installed Capital)** - The installed cost of $125,000 per gate for PCA was obtained from American Airline's *South Coast Airport Bubble Data Task Force Background Information: August 18-19, 1993* document (Reference 3) (see Appendix 2-5). It was assumed that this cost would be applicable for fixed gates.

- **PCA Cost per Gate (Energy)** - The monthly energy cost of $1,250 per gate for PCA was taken from an Aviation Systems, Inc. briefing to United Airlines at San Francisco International Airport (Reference 11). The energy cost was assumed to be equivalent to total O&M costs and applicable for fixed gates.

Figure 2-24 summarizes the installation and energy costs per gate for fixed ground power and PCA.

Calculation Methodology - Annual APU Mitigation Cost

For each airport, current gate status and requirements were analyzed year-by-year from 1997 through 2010, which covers the FIP control period from the first year of implementation to the final attainment date. It was assumed all FIP APU use restrictions would be met in the year in which it is required and not before.

The total installed capital cost for a given system is fully realized in the year in which it is installed. O&M costs occur each year beginning in the year the equipment is installed and continuing for the life of the equipment; in the case of fixed ground power and PCA until the attainment date. To calculate the cost of installing and operating fixed systems instead of APUs, the cost saved by not operating the APU is subtracted from the capital and O&M costs of the fixed (power and/or PCA) system:

FIGURE 2-24: FIXED SYSTEM COST INPUTS ($/gate)

Airport	Power Cost		PCA Cost	
	Installed Capital[1] ($/gate)	Energy ($/year/gate)	Installed Capital[2] ($)	Energy ($/year/gate)
Burbank (remote gates)	$40,000 $110,000	$5,160	$130,000	$15,000
John Wayne (remote gates)	$40,000 $110,000	$5,160	$130,000	$15,000
Long Beach (remote gates)	$40,000 $110,000	$5,160	$130,000	$15,000
Los Angeles Intl (remote gates)	$40,000 $110,000	$5,160	$130,000	$16,992
Ontario (remote gates)	$40,000 $110,000	$5,160	$130,000	$15,300
Sacramento Metro (remote gates)	$40,000 $110,000	$5,160	$130,000	$15,000

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1 Includes $5,000/gate for mobile back-up unit for ground power system.

2 Includes $5,000/gate for mobile back-up unit for PCA equipment.

$$C_Y = IC_{PWR} + IC_{PCA} + OMC_{PWR,Y} + OMC_{PCA,Y} - C_{APU,Y}$$

Where:

- C_Y - annual cost, in dollars per year, of installing (where necessary) and operating fixed systems instead of APUs in year Y of installation
- IC_{PWR} - installation cost, in dollars, of gates affected by fixed ground power system
- IC_{PCA} - installation cost, in dollars, of gates affected by fixed preconditioned air system
- $OMC_{PWR,Y}$ - annual O&M cost, in dollars per year, of gates affected by fixed ground power system in year Y
- $OMC_{PCA,Y}$ - annual O&M cost, in dollars per year, of gates affected by fixed preconditioned air system in year Y
- $C_{APU,Y}$ - annual cost, in dollars per year, of APUs affected in year Y
- Y - year of system(s) installation
- PWR - fixed ground power system
- PCA - fixed preconditioned air system

As mentioned above, for a given gate, IC_{PWR} and IC_{PCA} are zero after the first year of installation. Figures 2-25 and 2-26 summarize the South Coast and Sacramento, respectively, capital outlay and cash flow analysis for the APU emission mitigation requirements of the IFR. Appendix 2-7 is a summary of total annual APU cost outputs by APU requirement for each airport.

FIGURE 2-25: ANNUAL APU MITIGATION COST
SOUTH COAST AIR BASIN

Year	Power Capital Cost (IC_{PWR})	PCA Capital Cost (IC_{PCA})	Total Capital Cost (IC_{PWR} + IC_{PCA})	Power O&M Cost (OMC_{PWR})	PCA O&M Cost (OMC_{PCA})	Total O&M Cost (OMC_{PWR}+ OMC_{PCA})	Total Capital + O&M Costs	APU O&M Cost (C_{APU})	Total Annual APU Cost (C)
1997				($232,200)	($764,640)	($996,840)	($996,840)	$7,792,484	($6,795,644)
1998				($232,200)	($764,640)	($996,840)	($996,840)	$8,037,182	($7,040,342)
1999	$2,360,000	$17,290,000	$19,650,000	($918,480)	($2,888,160)	($3,806,640)	$15,843,360	$24,918,494	($1,461,853)
2000				($918,480)	($2,888,160)	($3,806,640)	($3,806,640)	$25,654,742	($21,848,103)
2001				($918,480)	($2,888,160)	($3,806,640)	($3,806,640)	$26,391,015	($22,584,376)
2002	$3,960,000		$3,960,000	($1,104,240)	($2,888,160)	($3,992,400)	($32,400)	$27,993,422	($20,041,022)
2003				($1,104,240)	($2,888,160)	($3,992,400)	($3,992,400)	$28,753,203	($24,760,803)
2004				($1,104,240)	($2,888,160)	($3,992,400)	($3,992,400)	$29,512,984	($25,520,584)
2005				($1,104,240)	($2,888,160)	($3,992,400)	($3,992,400)	$30,272,766	($26,280,366)
2006				($1,104,240)	($2,888,160)	($3,992,400)	($3,992,400)	$31,032,546	($27,040,146)
2007				($1,104,240)	($2,888,160)	($3,992,400)	($3,992,400)	$31,792,327	($27,799,927)
2008				($1,104,240)	($2,888,160)	($3,992,400)	($3,992,400)	$32,552,108	($28,559,710)
2009				($1,104,240)	($2,888,160)	($3,992,400)	($3,992,400)	$33,311,889	($29,319,489)
2010				($1,104,240)	($2,888,160)	($3,992,400)	($3,992,400)	$34,071,670	($29,961,872)

NOTE: Cost abbreviations are in parentheses, based on the equation in the Annual APU Mitigation Cost discussion:

$$C_Y = IC_{PWR} + IC_{PCA} + OMC_{PWR,Y} + OMC_{PCA,Y} - C_{APU,Y}$$

Negative costs are shown in parentheses and reflect a cost savings to the regulated community.

FIGURE 2-26: ANNUAL APU MITIGATION COST SACRAMENTO AIR BASIN

Year	Power Capital Cost (IC_{PWR})	PCA Capital Cost (IC_{PCA})	Total Capital Cost (IC_{PWR} + IC_{PCA})	Power O&M Cost (OMC_{PWR})	PCA O&M Cost (OMC_{PCA})	Total O&M Cost (OMC_{PWR} + OMC_{PCA})	Total Capital + O&M Costs	APU O&M Cost (C_{APU})	Total Annual APU Cost (C)
1997				($15,840)	($45,000)	($60,840)	($60,840)	$124,283	($63,803)
1998				($15,480)	($45,000)	($60,840)	($60,840)	$126,796	($66,316)
1999	$440,000	$1,430,000	$1,870,000	($72,240)	($210,000)	($282,840)	$1,587,760	$603,447	$1,548,793
2000				($72,240)	($210,000)	($282,840)	($282,840)	$611,681	($329,441)
2001				($72,240)	($210,000)	($282,840)	($282,840)	$621,987	($339,747)
2002	$330,000		$330,000	($87,720)	($210,000)	($297,720)	$32,280	$655,117	($27,397)
2003				($87,720)	($210,000)	($297,720)	($297,720)	$665,795	($368,075)
2004				($87,720)	($210,000)	($297,720)	($297,720)	$676,472	($378,752)
2005				($87,720)	($210,000)	($297,720)	($297,720)	$687,149	($389,429)
2006				($87,720)	($210,000)	($297,720)	($297,720)	$687,149	($389,429)
2007				($87,720)	($210,000)	($297,720)	($297,720)	$687,149	($389,429)
2008				($87,720)	($210,000)	($297,720)	($297,720)	$687,149	($389,429)
2009				($87,720)	($210,000)	($297,720)	($297,720)	$687,149	($389,429)
2010				($87,720)	($210,000)	($297,720)	($297,720)	$687,149	($389,429)

NOTE: Cost abbreviations are in parentheses, based on the equation in the Annual APU Mitigation Cost discussion:

$$C_Y = IC_{PWR} + IC_{PCA} + OMC_{PWR,Y} + OMC_{PCA,Y} - C_{APU,Y}$$

Negative costs are shown in parentheses and reflect a cost savings to the regulated community.

2.3.3 Ground Support Equipment

A wide variety of equipment services commercial aircraft while they are unloading and loading passengers and freight at an airport. As a group, ground support equipment (GSE) include primarily the following types of equipment.

- **Aircraft Tugs** - Tow aircraft in the terminal gate area. They also tow aircraft to and from hangers for maintenance.
- **Air Start Units** - Provide large volumes of compressed air to an aircraft's main engines for starting.
- **Belt Loaders** - Mobile conveyor belts used to move baggage between the ground and the aircraft hold.
- **Baggage Tractors** - Haul baggage between the aircraft and the terminal.
- **Air-Conditioning Units** - Provide conditioned air to ventilate and cool parked aircraft.
- **Ground Power Unit (GPU)** - Mobile ground-based generator units that supply aircraft with electricity while they are parked at the airport.
- **Cargo Moving Equipment** - Various types of equipment employed to move baggage and other cargo around the airport and to and from aircraft. This category includes forklifts, lifts, and cargo loaders.
- **Service Vehicles** - Specially modified vehicles to service aircraft at airports and include fuel trucks, maintenance trucks, service trucks, lavatory trucks, and bobtail tractors (a truck body that has been modified to tow trailers and equipment).

Buses, cars, pickups, and vans utilized in GSE operations are viewed somewhat differently than the above equipment. These vehicles typically are certified for on-highway use by the State of California. Vehicles certified for on-highway use by the state are presently subject to state and federal emissions regulations. As such their emissions are relatively much lower than off-highway vehicles that are not required to meet a specific emissions standard. Highway certified vehicles also are used primarily for transportation and have a longer daily range than is common for most GSE.

As with APUs, GSE do not appear in the inventory for air taxi and smaller air carrier aircraft since these aircraft generally do not require GSE. For example, Oxnard/Ventura County Airport does not reflect any GSE emissions since all aircraft that operate at the airport are air taxi or small air carrier aircraft. Also, very little information was available on the turbine-powered air start units, such as engine size and operating practice. For the few instances where turbine-powered air start units appeared in the inventory, it was assumed the service was provided by an APU.

The balance of Section 2.3.3 describes the baseline GSE emission inventory, a GSE emission forecast, and a recommended control strategy. The section ends with a discussion of the cost to control GSE emissions.

2.3.3.1 1990 GSE Emissions Inventory and Emissions Forecast

In their *Comments of the Air Transport Association on EPA's Proposed Federal Implementation Plan Measures for Commercial Aviation* (Reference 2), the ATA submitted an estimate of GSE 1990 emissions for the South Coast Air Basin (see Figure 2-27). The off-road portion of this estimate was 85% and 99% higher for HC and NO_x, respectively, than EEA estimated for the proposed rule (see 1994 TSD (Reference 7)). Since the ATA reportedly made its estimate based on extensive primary data provided by their member air carriers, EEA accepted this as the baseline inventory for the South Coast Air Basin. The difference primarily was due to a higher equipment population at the smaller airports and a much higher annual use rate for most equipment types. For the Sacramento Air Basin, EEA used the baseline inventory calculated by EEA using the methodology described in the 1994 TSD (Reference 7), adding ILEV emissions and increasing the population and usage rates based on ATA comments (see calculation methodology discussion below). The ATA did not provide a detailed estimate of the GSE population by equipment type, however, which is needed to forecast GSE emissions. Although the ATA did forecast GSE emissions, the methodology did not account for the effects of aircraft fleet turnover. EEA forecast GSE emissions based on ATA's

FIGURE 2-27: SUMMARY OF GSE EMISSIONS - 1990
(lb/yr)

SOUTH COAST AIR BASIN[1]		
Airport	**HC**	**NO_x**
Burbank	29,265	77,021
John Wayne	46,359	122,167
Long Beach	14,728	73,098
Los Angeles Intl	707,191	1,913,682
Ontario Intl	81,819	228,748
Basin Total:	879,362	2,414,716

SACRAMENTO AIR BASIN[2]		
Airport	**HC**	**NO_x**
Sacramento Metropolitan	31,070	92,279

[1] SOURCE: *Comments of the Air Transport Association on EPA's Proposed Federal Implementation Plan Measures for Commercial Aviation* (Reference 2).
[2] SOURCE: EEA memorandum *Technical Support Document Errata* (Reference 18), recalculated after doubling the population based on ATA comments and adding ILEV emissions.

baseline emissions using the forecasting methodology developed for the 1994 TSD (Reference 7), which uses the aircraft class and corresponding LTOs projected for the aircraft forecast to estimate a new total population of GSE. Figure 2-28 summarizes the GSE population forecast by year and airport. Appendix 2-8 contains GSE populations by forecast year, airport, and equipment type.

Calculation Methodology

As described in the 1994 TSD (Reference 7), data from six carriers were used to develop a population estimation method. Through regression analysis of GSE populations and airport activity, it was found that GSE populations most directly correlated to aircraft operations (expressed in LTOs). The best statistical representation used two separate equations to estimate the population of GSE at commercial airports. Both equations describe a linear relationship between GSE population and the level of activity represented by the total airport LTOs. For large air carriers at LAX[1], the estimation equation is:

$$P_{LAX} = k + (RC \times LTO_{LAX})$$

Where: P_{LAX} = GSE population at LAX for large air carriers

k = 135.5; constant for large air carriers at LAX

RC = 0.00575; regression coefficient for large air carriers at LAX

LTO_{LAX} = number of large air carrier aircraft LTOs at LAX

At all other airports, and smaller operations at LAX, the sampled airlines were found to utilize GSE at a different rate:

[1] For the purposes of this analysis, large air carriers were airlines with greater than 1000 wide body operations at LAX in 1990.

FIGURE 2-28: SUMMARY OF GSE POPULATIONS FORECAST

SOUTH COAST AIR BASIN				
Airport	**1990**	**2000**	**2005**	**2010**
Burbank	150	206	242	260
John Wayne	178	254	288	312
Long Beach	74	102	108	132
Los Angeles Intl	1,235	1,769	1,890	2,107
Ontario Intl	224	302	344	388
Basin Total:	1,861	2,633	2,872	3,199

SACRAMENTO AIR BASIN				
Airport	**1990**	**1999**	**2000**	**2005**
Sacramento Metropolitan	188	238	240	254

$$P_{OTHER} = k + (RC \times LTO_{OTHER})$$

Where: P_{OTHER} = GSE population at all other airports and for small air carriers at LAX

k = 8.23 constant for other air carriers

RC = 0.0022 regression coefficient for other air carriers

LTO_{OTHER} = number of aircraft LTOs at all other airports and for small air carriers at LAX

The difference in GSE population between LAX and other airports is due to the reliance upon LAX as a major transfer point for the larger airlines and as a gateway to Asian destinations. The large airlines operating at LAX must also equip their GSE operations to handle the large daily "rush hour" of travel, which requires a higher concentration of GSE to service all of the aircraft without delay.

Based on the ATA inventory data, the regression equation for the airports other than LAX appears to estimate a population that is 50% too low. Multiplying this equation by 2 gives the new values of 16.46 for the constant k and 0.0044 for the regression coefficient RC. Using these new values to calculate P_{OTHER} gives a baseline emissions estimate very similar to that reported by the ATA. This modified equation was used to forecast GSE populations for estimating future GSE emissions at all FIP airports and calculating a baseline inventory for the Sacramento Air Basin. The overall result of this change was to increase the total GSE population in the South Coast Air Basin by 20%.

After estimating the total population of GSE at airports in the air basins for the given forecast years (2000, 2005, and 2010 for the South Coast Air Basin and 1999, 2000, and 2005 for the Sacramento Air Basin), the equipment types (e.g., baggage tractors) were assumed to be represented in the total equipment populations in the same proportion as they were represented in the GSE operations as reported earlier by the six air carriers. In all cases, it was assumed that the GSE populations increased in a step-like fashion, with no changes in the population of a GSE type until the forecast year. For example, no changes in the 1990 baseline population were assumed to occur until the forecast year 2000 (or 1999 for Sacramento Metropolitan Airport). For a more detailed discussion of forecasting GSE populations see EEA memorandum *GSE Emissions* (Reference 20) dated July 18, 1994, which is included in the docket. Figure 2-28 summarizes the GSE populations forecast by year and airport. Appendix 2-8 contains GSE population forecasts by year, airport, and equipment type.

2.3.3.3 Mitigation of GSE Emissions

The intent of the IFR is to require the use of the lowest-emitting GSE possible. For that reason EPA will require the use of zero-emission GSE vehicles wherever possible. In practice this will mean electrification of GSE vehicles as discussed below, given the current availability of electric technology for use in GSE applications and the likelihood of such technology or other zero-emission technology being developed and commercialized over the course of the FIP control period. Electric technology for many GSE applications is currently available or will be developed over the course of the control period. Electric technology for certain GSE vehicles is not expected to be developed in the foreseeable future, however. This is mainly a consequence of the long distances that these vehicles must travel routinely, and the resultant difficulty of electrifying such equipment, which typically are powered by engines between 120 horsepower and 230 horsepower. EPA therefore will rely upon Inherently Low Emission Vehicle (ILEV) requirements, as established elsewhere in the FIP, as a means of reducing emissions from GSE in this category.

While the intent of the FIP is to reduce emissions during the ozone season, benefits will accrue throughout the year once equipment is converted. Discussions in this section assume full year operation of the affected GSE.

In comments on the proposed rule, American Airlines proposed converting GSE to electricity and alternative fuels. American commented that "[t]o date, the only pieces of GSE equipment that American would not be capable of converting to electric include: (1) on-line generators; (2) on-line air start unit; and (3) large long distance towing push-out tractors. The load requirement of these particular pieces of equipment would make it impractical to convert to electric,..." (*Comments of American Airlines, Inc. on the Commercial Airline Measures Proposed by the United States Environmental Protection Agency for the California South Coast Air Basin*, page 44 (Reference 4)).

Other commercial air carriers provided information on GSE by fuel type, in data submitted to EPA by the ATA and in comments submitted to the docket. In this listing, several categories of GSE (i.e., narrow-body aircraft tugs, baggage tugs, cars, forklifts, and cargo lifts) include electric powered equipment that already are in use in the South Coast. Those five equipment types represent more than half of the total GSE population.

EEA concludes from this information that electrically-operated equipment are commercially available as alternatives to most of the existing gasoline and diesel-fueled off-road equipment. The equipment applications that have not been demonstrated commercially as amenable to electrification are those requiring high loads for long duty cycles, as noted by American Airlines. Elsewhere in this document, EEA has noted that fixed ground power systems can displace the need for fuel-fired on-line generators (see Section 2.3.2.3). Also, main engine air start is an essential use of the APU. These are two of the three applications noted in comments received from the airlines as being difficult to electrify. EEA believes that the difficulties of electrifying the other high load, long duty cycle applications, such as long distance towing, can be solved through technology development. The primary limitation is the present state of battery technology. Considerable research and development on battery technology is underway currently, primarily to support on-road, electric vehicle applications. While EEA believes advances in battery technology will be forthcoming, we recommend that EPA delay the electrification requirements for the most difficult applications until the attainment deadline to give the GSE manufacturers sufficient time to develop and demonstrate this new equipment.

In comments submitted to the docket on November 7, 1994 (*American Airlines, Inc.'s Proposed Commercial Aviation Operations Emission Rule for the South Coast Air Quality Management District* (Reference 5)), American Airlines proposed the GSE conversion schedule shown in Figure 2-29. As shown the American proposal covered the entire GSE fleet (on-road and off-road vehicles) and included CNG and LNG in addition to electricity. American's final target includes conversion of 100% of the GSE fleet with 70% of the fleet being electrified. The 70% of the fleet (as measured in horsepower) to be electrified is comparable to EEA's estimate of the off-road portion of the total GSE fleet.

FIGURE 2-29: AMERICAN AIRLINES' GSE CONVERSION SCHEDULE

Effective Date	Percentage of GSE Fleet BHP Powered by Alternative Fuels (CNG, LNG, & Electricity)	Percentage of GSE Fleet BHP Powered Solely by Electricity
January 1, 1996	60%	30%
January 1, 1998	80%	40%
January 1, 2000	90%	50%
January 1, 2005	100%	60%
January 1, 2010	100%	70%

SOURCE: *American Airlines, Inc.'s Proposed Commercial Aviation Operations Emission Rule for the South Coast Air Quality Management District* (Reference 5)

The Air Transport Association (ATA) in its comments proposed that GSE operators in the South Coast Air Basin be required to convert GSE to "alternative technology" other than conventional gasoline- or diesel-fueled engines, as shown in Figure 2-30:

FIGURE 2-30
AIR TRANSPORT ASSOCIATION PROPOSED CONTROL PROGRAM

Implementation Deadline	Percentage of Basin-Wide Fleet Comprised of Alternative Technology GSE
December 31, 1997	25%
December 31, 2001	50%
December 31, 2003	80% (of which 50% shall be electrically-powered)

EEA believes that American's proposed phase in schedule is overly aggressive for the earliest deadlines, but that the increments are directionally correct. An effective date of January 1, 1996 does not allow the air carriers operating at the FIP area airports enough time to requisition the substantial amount of equipment needed to meet the proposed conversion target. Also the phase-in schedule is based on GSE horsepower. While this approach insures that meaningful reductions are made early in the control period, it limits the flexibility of individual carriers to meet their specific needs. To maximize each air carrier's flexibility to meet the rule, EEA proposes establishing a conversion schedule based on the total population of GSE subject to electrification (i.e., off-road equipment).

EEA also recommends establishing a minimum horsepower rating for equipment subject to the conversion requirement. It is not EPA's intent that small, hand-held equipment, such as string trimmers, lawn mowers, and leaf blowers, be included in this rule. A 20 horsepower minimum cut-off would eliminate the small equipment without compromising EPA's intent to reach the equipment that supports aircraft operations. This has the additional effect of insuring that a conversion schedule based on population will result in significant reductions in the earliest phase of the control period. One exception to the minimum horsepower is small auxiliary engines mounted on a vehicle. These engines should be converted to use the same fuel as the engine used for propulsion, typically electricity. In many cases, these auxiliaries are hydraulic powered by the vehicle's main engine already and so will not require "conversion."

In establishing a conversion schedule, EPA's objective is to achieve early emission reductions but not to exceed the technological capability or production capacity of the equipment available at the effective conversion date. EEA developed a conversion scenario that we believe meets these guidelines. Figure 2-31 shows the forecast population of GSE in the South Coast and a possible conversion schedule we believe is aggressive but technically feasible. The first conversion increment is to achieve substantial early reductions. In this increment EEA assumed 100% conversion of bag tugs, carts, and forklifts and 25% conversion of narrow body aircraft tugs to electricity. Commercial versions of each of these equipment types are available currently. In fact, electric versions of each type are prevalent in the South Coast today. EEA has held discussions with vendors of this equipment who anticipate no limits on production capacity. Two years should be adequate for the airlines to acquire the equipment to meet this requirement.

EEA believes that the electric power requirements for recharging the electric equipment in this first conversion increment can be met through the existing power supply system. Primary charging can take place overnight when other airport power demands are minimal and power rates are lowest. Opportunity charging, which occurs throughout the day, necessarily takes place during periods of low activity when the equipment can be idle. This includes periods when no aircraft are docked at the gates or perhaps during periods of flight delays. This coincides with idle periods for other power consuming equipment such as the passenger access bridge. As additional equipment is connected

FIGURE 2-31: POSSIBLE GSE CONVERSION SCENARIO

Equipment Types	Population - South Coast				% of Fleet	% Conversion - 1990 Population Basis			
	1990	2000	2005	2010		Increment 1	Increment 2	Increment 3	Increment 4
Aircraft Tug NB	74	100	109	119	4.7%	25%	75%		
Aircraft Tug WB	3	6	7	8	0.2%				100%
Air Conditioner[1]									
Air Start[1]									
Bag Tug	452	636	690	771	28.7%	100%			
Belt Loader	193	271	295	329	12.2%		100%		
Bobtail	44	58	65	74	2.8%			100%	
Bus[2]									
Car[2]									
Cargo Loader	80	114	128	140	5.1%		100%		
Cart	73	103	112	126	4.6%	100%			
Deicer	15	19	20	21	1.0%		100%		
Forklift	177	251	274	301	11.2%	100%			
Fuel Truck[2]									
GPU[1]									
Lav Cart	9	15	16	17	0.6%			100%	
Lav Truck	32	45	47	53	2.0%			50%	50%
Lift	57	82	90	97	3.6%		100%		
Maintenance Truck	109	158	172	196	6.9%			100%	

FIGURE 2-31: POSSIBLE GSE CONVERSION SCENARIO
(Concluded)

	Population - South Coast					% Conversion - 1990 Population Basis			
Equipment Types	1990	2000	2005	2010	% of Fleet	Increment 1	Increment 2	Increment 3	Increment 4
Other	86	121	133	151	5.5%		50%	50%	
Pickup	106	154	166	189	6.7%			100%	
Service Truck	63	91	100	108	4.0%			100%	
Van[2]									
Water Truck	3	5	5	8	0.2%			100%	
TOTAL[3]:	1,576	2,229	2,429	2,708		46%	29%	24%	1%

1 Excluded from conversion requirements.

2 On-road vehicles to be converted to meet ILEV standard.

3 % Conversion Totals represent percent of GSE fleet in units of equipment.

and opportunity charging power requirements increase, it most likely will be necessary that the power distribution system at many or all of the airports will need to be expanded.

In the next increment EEA assumed that 100% of the belt loaders, cargo loaders, deicers, lav carts, and lifts and the balance of the narrow body aircraft tugs are electrified along with 50% of the equipment included in the "Other" category, which includes sweepers, mobile stairs, and other miscellaneous equipment. Electric versions of much of this equipment are in service in the South Coast today and EEA believes these vehicles could be electrified by 2000. One possible exception is the heavy-lift cargo loaders (greater than 30,000 pounds capacity). Because of their power requirement and duty cycle, the large loaders may not be amenable to electrification with current technology. EEA believes these are relatively few in number, although industry did not provide this type of information in previous data submittals. The next increment in EEA's possible conversion scenario includes most of the rest of the vehicle types with the exception of wide body aircraft tugs and half of the lav trucks. These vehicles have heavy loads and long operating cycles and often must travel significant distances on the airport (e.g., five mile round trips when towing aircraft from a passenger gate to a maintenance position). This equipment is included in the final conversion increment with a conversion target of 2010 to allow for technology development to meet these demanding requirements.

On the basis of EEA's possible GSE conversion scenario the following percentages of the GSE population would be converted:

Increment 1 - 46% converted within 2 years
Increment 2 - 29% converted within 5 years
Increment 3 - 24% converted within 10 years
Increment 4 - 1% converted within 15 years

EEA believes these conversion increments are feasible for the South Coast Air Basin as a whole. However, when this is applied to individual GSE fleets operated by air carriers or FBOs, numerous exceptions and special cases may exist that would render this schedule too aggressive. To give the regulated community more flexibility to meet the conversion schedule, EEA recommends extending the requirements for some equipment to later in the control period.

Based on this analysis, EEA recommends that EPA require each GSE operator to convert to zero-emission engines (e.g., electrify) the following minimum percentages (population basis) of its total off-road GSE fleet on the following schedule:

Phase 1 - 44 percent by February 14, 1997;
Phase 2 - 62 percent by January 1, 2000;
Phase 3 - 90 percent by January 1, 2005; and
Phase 4 - 100 percent by January 1, 2010.

Figure 2-32 shows a detailed conversion scenario by year for each GSE type that EEA used to analyze the emissions and cost impact of this rule based on these four phases. For each GSE type, separate conversion schedules are shown for base and growth populations. The base population is the number of equipment in the baseline (1990) inventory. The growth population is the number of equipment added to the base population in a particular year due to growth. Appendix 2-8 includes the annual population of converted equipment by equipment type for each airport.

GSE vehicles that either are or are derived from on-road vehicles are a special case. These vehicles currently are lower emitting than other GSE because they meet on-road emission standards. Also, because many of these vehicles are used to transport people, cargo, and equipment off the airport property they have long duty cycle requirements. As such, these vehicles are difficult and/or expensive to electrify using current technology. EPA and the state of California have worked with the auto, truck, bus, and engine manufacturers to develop new on-road vehicle technology that will meet strict new

FIGURE 2-32: GSE CONVERSION SCHEDULE

GSE Type	Population	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Aircraft Tug NB	Base				25%			75%										
	Growth							100%					100%					100%
Aircraft Tug WB	Base																	100%
	Growth																	100%
Air Conditioner[1]	Base																	
	Growth																	
Air Start[1]	Base																	
	Growth																	
Bag Tug	Base				100%													
	Growth				100%		100%	100%					100%					100%
Belt Loader	Base							100%										
	Growth							100%					100%					100%
Bobtail	Base												100%					
	Growth												100%					100%
Bus	Base							30%					70%					
	Growth												100%					100%
Car	Base						50%						50%					
	Growth												100%					100%
Cargo loader	Base							100%										
	Growth							100%					100%					100%
Cart	Base				100%													
	Growth				100%			100%					100%					100%
Deicer	Base							100%										
	Growth							100%					100%					100%
Forklift	Base				100%													
	Growth				100%			100%					100%					100%
Fuel Truck	Base							30%					70%					
	Growth												100%					100%

FIGURE 2-32: GSE CONVERSION SCHEDULE
(Concluded)

GSE Type	Population	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
GPU[1]	Base																	
	Growth																	
Lav Cart	Base							100%										
	Growth							100%					100%					100%
Lav Truck	Base												50%					50%
	Growth												100%					100%
Lift	Base							100%										
	Growth							100%					100%					100%
Maintenance Truck	Base												100%					
	Growth												100%					100%
Other	Base							50%					50%					
	Growth												100%					100%
Pickup	Base												100%					
	Growth												100%					100%
Service Truck	Base												100%					
	Growth												100%					100%
Van	Base						50%						50%					
	Growth												100%					100%
Water Truck	Base												100%					
	Growth												100%					100%

1 This GSE type is not targeted for being converted to electric.

emissions standards. EEA believes that replacing all on-road GSE with new vehicles that meet low emission standards as this new technology becomes available is a more prudent strategy than requiring electrification, and achieves nearly the same total emissions reductions. EEA recommends that EPA require the replacement of existing on-road GSE with new equipment that meets the ILEV standards on the following schedule:

a. 50% of light-duty GSE vehicles by January 1, 1999

b. 30% of medium- and heavy-duty vehicles by January 1, 2000

c. 100% of all on-road GSE vehicles (light-, medium-, and heavy-duty vehicles) by January 1, 2005.

The intent of this recommendation is to give GSE owners and operators a low emitting alternative where it is impractical to electrify because of on-highway travel needs, and not to encourage GSE owners and operators to convert their GSE fleet to vehicles certified for on-road use. According to the data submitted to EPA by the Air Transport Association and individual air carriers, most buses, cars, fuel trucks, and vans are powered by engines in the 120 to 230 horsepower range. EEA recommends that EPA adopt this as the range of applicability to limit the number of vehicles required to meet the ILEV standards. EEA further recommends that EPA not allow tampering with the emissions controls on these vehicles and to require the use of highway fuels only. Although many airlines presently use Jet A rather than diesel in some GSE because it is cheap and readily available at the airport, sulfur or other constituents in Jet A could damage the emissions controls needed to insure the ILEV's emission performance.

Calculation Methodology - Annual GSE Emissions Benefit

Annual off-road GSE emissions mitigated due to the FIP GSE requirements were estimated using the same methodology as used for the proposed rule. For a more detailed discussion of forecasting off-road GSE populations see EEA memorandum *GSE Emissions* (Reference 20). As discussed earlier, baseline GSE population and annual usage hours were updated based on data submitted by ATA during the comment period on the FIP proposal.

To calculate emissions from GSE certified for on-road use, such as buses, cars, fuel trucks and vans, EEA used CALI5 to calculate average emissions from typical vehicles that fall into these classes, using the fuel mix reported by ATA and individual air carriers for this equipment. EEA assumed an average vehicle speed of 20 miles per hour. The average trip length was based on the average annual hours of operation, again as reported by ATA. The fleet profile was determined by CALI5 for the four years for which emissions were calculated: 1990, 2000, 2005, and 2010. Evaporative emissions were calculated for hot soak, diurnal, crankcase, refueling, and resting losses. To simplify the analysis, EEA assumed the ILEVs met a zero emission standard so the benefit due to conversion of these vehicles is equal to the emissions calculated assuming a standard (non-ILEV) fleet mix. This overstates the benefit somewhat even if some carriers may choose to electrify this equipment. These vehicles represent only a small fraction of the total emissions from all GSE, however.

Data Sources

Data Sources needed for calculating the annual GSE emissions mitigated due to the FIP requirements are population, horsepower, load factors, emission factors, usage, economic life, and conversion schedule. The use of the ATA data for forecasting GSE population was discussed earlier. The sources of horsepower, load factors, and off-road emission factors are the same as those used for the proposed rule (see 1994 TSD (Reference 7)). The remaining inputs are discussed below.

- **On-Road Emissions** - As described above, the emissions from on-road vehicles were determined using CALI5.

- **Usage** - The average operation of each GSE type was obtained from *Comments of the Air Transport Association on EPA's Proposed Federal Implementation Plan Measures for Commercial Aviation* (Reference 2).

- **Economic Life** - The economic life refers to the average number of years a new piece of equipment is projected to be used. The economic life, also known as the planning life, of GSE was determined based on information provided by American Airlines, Inc. In reality the useful life of a piece of equipment is much longer than its initial economic life due to rebuilding and remanufacture options. Using economic life gives a conservative result.

- **GSE Conversion Schedule** - The proposed GSE conversion schedule was discussed earlier. Conversion targets by GSE type are listed in Figure 2-31.

Figure 2-33 summarizes the usage and economic life inputs by GSE type.

Figure 2-34 summarizes the GSE emission benefit for the South Coast and Figure 2-35 the same information for Sacramento. Appendix 2-8 includes a detailed summary of annual GSE emissions benefits. The data is organized by GSE type and airport. Annual on-road GSE emissions mitigated were estimated using the populations identified in the above (as with off-road GSE). (The information in Appendix 2-8 was created for the Regulatory Impact Analysis (RIA) for the FIP. For more information on the data in this appendix, please see the RIA, published separately.)

2.3.3.4 Cost of Mitigating GSE Emissions

The following summarizes the inputs and calculations for determining the capital cost requirements and cash flow impact of the GSE requirements in the IFR. To determine the cost impact, the cost of operating conventional GSE is compared to the cost of operating GSE converted due to the FIP requirements.

Calculation Methodology - Annual GSE Conversion Cost

For each airport and GSE type, the annual cost of electric- versus conventional- fueled GSE were analyzed by equipment type and year from 1997 through 2020 using the capital and O&M costs and the proposed conversion schedule described above. It was assumed that none of the FIP GSE use restrictions would be met until the required date. Therefore, the GSE populations increased in a step-wise fashion, with no changes in the

FIGURE 2-33: GSE USAGE AND ECONOMIC LIFE INPUTS[1]

Equipment Type	Average Operation[2] (hours/year)	Economic Life (years)
AIRCRAFT TUG NB	1,721	10
AIRCRAFT TUG WB	1,721	10
AIR CONDITIONER	271	8
AIR START	181	8
BAG TUG	1,021	8
BELT LOADER	887	8
BOBTAIL	434	8
BUS	1,678	8
CAR	486	8
CARGO LOADER	1,250	10
CART	340	8
DEICER	156	8
FORKLIFT	1,028	8
FUEL TRUCK	1,117	8
GPU	2,240	8
LAV CART	725	8
LAV TRUCK	735	8
LIFT	1,357	8
MAINTENANCE TRUCK	563	8
OTHER	771	8
PICKUP	1,722	8
SERVICE TRUCK	563	8
VAN	1,987	8
WATER TRUCK	567	8

1 Sources:
Average Operation - *Comments of the Air Transport Association on EPA's Proposed Federal Implementation Plan Measures for Commercial Aviation* (Reference)
Economic Life - American Airlines, Inc.

2 Refers to average operation per unit (hours/year)

FIGURE 2-34: GSE EMISSION BENEFIT
SOUTH COAST AIR BASIN

Year	HC (lbs)	NO_x (lbs)
1997	192,553	450,219
1998	192,553	450,219
1999	193,979	450,876
2000	459,039	1,273,467
2001	459,039	1,273,467
2002	459,039	1,273,467
2003	459,039	1,273,467
2004	459,039	1,273,467
2005	611,445	1,530,927
2006	437,013	1,165,496
2007	437,013	1,165,496
2008	418,175	1,079,375
2009	241,734	767,490
2010	332,474	1,055,456

FIGURE 2-35: GSE EMISSION BENEFIT SACRAMENTO AIR BASIN

Year	HC (lbs)	NO_x (lbs)
1997	20,648	50,364
1998	20,648	50,364
1999	20,781	50,425
2000	44,333	131,427
2001	44,333	131,427
2002	44,333	131,427
2003	44,333	131,427
2004	44,333	131,427
2005	56,679	153,799
2006	38,883	116,688
2007	38,883	116,688
2008	35,931	103,365
2009	21,881	79,750
2010	22,333	80,190

population of a GSE type until the requirement year. It was assumed that one recharger station was installed for each electric GSE. The recharger capital cost was estimated by American Airlines, Inc., and includes a minimum for additional wiring from the terminal to each recharge station.

To calculate the annual cost of electric versus conventional fueled GSE due to the IFR, the cost difference between purchasing a conventional versus electric GSE and the cost difference between operating and maintaining a conventional versus electric GSE was calculated by each GSE type. The capital cost difference between conventional and electric GSE was calculated by subtracting the electric GSE capital cost from the conventional GSE capital cost for each GSE type. (An electric GSE and recharger costs more to purchase than a conventional GSE, except for carts where the conventional GSE was assumed to be electric.) (EEA did not include benefits that may be available from tax credits for the purchase of alternative fuel vehicles at either the federal or state level. Such credits would improve the economic feasibility of converting to alternative fuels, including electricity.)

The operating and maintenance cost difference between a conventional and electric GSE was calculated by subtracting the electric GSE O&M cost from the conventional GSE O&M cost for each GSE type. (For most GSE types it costs less to operate and maintain an electric GSE and recharger than a conventional GSE, with a resultant cost savings for O&M.) Appendix 2-9 contains capital and O&M cost differences between conventional and electric GSE for each GSE type. (The information in Appendix 2-9 was created for the RIA for the FIP. For more information on the data in this appendix, please see the RIA, published separately.)

The capital cost for ILEVs was assumed to be a premium of $2,000 for light- and medium-duty vehicles and $4,000 for heavy-duty vehicles compared to conventional equipment used in these applications. The operating and maintenance costs for the ILEVs was assumed to be the same as for the conventional equipment.

For each year the cost for purchasing (where necessary), operating, and maintaining each GSE type was calculated. The annual electric purchases and operations were estimated based on the proposed conversion schedule and each airport's baseline and forecast populations. Costs were developed based on the number of electric units purchased or operated for this component of the technical analysis. It is assumed that when an electric GSE was purchased it meets the requirements for a new GSE somewhere in the owners/operators' system. Even if an airline did not need new equipment at that particular airport, it is assumed that the equipment was needed somewhere in an airline's system. In this case an electric GSE is assumed to have been purchased and swapped with a conventional GSE of the same type at an airport in the FIP areas. Therefore, only the additional cost of the electric equipment compared to the cost of a conventional gasoline or diesel vehicle is assessed to the cost of the regulation, not the entire new equipment cost. The freight cost to move the conventional equipment to another location is assumed to be 5% of the original equipment cost. The annual cash flow impact of converting GSE to electric for a particular GSE type is the net capital cost plus the net O&M costs:

$$C_Y = (CC_E + CC_{ER} - CC_C) \times EU_P + (OMC_E - OMC_C) \times EU_O$$

Where:

- C_Y - annual cost of purchasing (where necessary) and operating electric equipment instead of conventional equipment for a particular equipment type T in year Y
- CC_E - capital cost of purchasing an electric piece of equipment
- CC_{ER} - capital cost of purchasing an electric recharger for an electric piece of equipment
- CC_C - capital cost of purchasing a conventional piece of equipment
- EU_P - number of electric units purchased
- OMC_E - annual O&M cost of operating and maintaining an electric piece of equipment operated
- OMC_C - annual O&M cost of operating and maintaining a conventional piece of equipment operated

EU_O - number of electric units operated
Y - the year

This calculation is performed by year for each equipment type, then summed over all equipment types for each year to get a total cash flow impact for each year. It was assumed that any capital costs associated with purchasing a piece of equipment were fully realized in the first year of the equipment's life. Therefore, for subsequent years of the equipment's operation the only cost is for operating and maintenance (i.e., capital costs are zero). It was assumed that no electric purchases or costs occurred until the first applicable requirement.

Data Sources

The data needed for calculating the cost impact of the GSE requirements of the RIA are annual usage, economic life, population, conventional GSE capital costs, conventional GSE operating and maintenance cost, electric GSE capital costs, electric GSE operating and maintenance costs, electric GSE recharger capital costs, and the GSE conversion schedule. The sources of population, usage, and economic life data and the proposed conversion schedule are the same as in the emissions mitigation calculations (see Section 2.3.3.3 and Figures 2-31 and 2-33). The sources of the remaining inputs are identified below:

- **Conventional GSE Capital Cost** - The off-road and on-road conventional GSE capital costs (per piece of equipment) were provided by American Airlines, Inc. The costs were based on recent purchases by American Airlines, Inc.

- **Conventional GSE O&M Cost** - The off-road and on-road conventional GSE maintenance costs (per piece of equipment) were based on 1994 maintenance cost data provided by American Airlines, Inc. The operating costs (fuel) were estimated by EEA based on fuel consumption rates and annual hours of usage.

- **Electric GSE Capital Cost** - The off-road electric GSE capital costs (per piece of equipment) were provided by American Airlines, Inc. The costs were based on recent purchases by American Airlines, Inc. and vendor bids. For all off-road electric GSE (except carts, deicers, and lav carts), 5% was added to the capital costs (per unit) for shipping (the conventional piece of equipment the electric version is replacing) to a station outside of the FIP area for reuse. The on-road GSE capital costs listed for electric are actually ILEV costs. As mentioned earlier, a $2,000 premium for light- and medium-duty vehicles and a $4,000 premium for heavy-duty vehicles was assumed.

- **Electric GSE O&M Cost** - The off-road electric GSE operating and maintenance costs (per piece of equipment) were estimated by EEA based on data compiled from the literature. The on-road GSE operating and maintenance costs listed for ILEVs are the same as for conventional on-road GSE.

- **Electric GSE Recharger Capital Cost** - The electric GSE recharger capital costs (per piece of equipment) were provided by American Airlines, Inc. The costs were based on recent purchases by American Airlines, Inc.

Figure 2-36 summarizes the capital, operating, and maintenance costs by equipment type for conventional and electric GSE.

Figure 2-37 summarizes the cost impact of the GSE requirements of the IFR for the South Coast and Figure 2-38 presents the same information for Sacramento. While the total capital outlay is substantial, the cash flow analysis shows that this expenditure is quickly recouped and results in a net cost savings.

FIGURE 2-36: CAPITAL AND O&M COST INPUTS

Equipment Type	Conventional GSE Cost		Electric GSE Cost		Recharger Cost
	Capital ($000)	O&M ($/hr)	Capital[1] ($000)	O&M ($/hr)	Installed Capital ($/electric unit)
AIRCRAFT TUG NB	$100.0	$16.67	$126.0	$12.50	$2,500
AIRCRAFT TUG WB	$190.0	$26.41	$262.5	$19.71	$2,500
AIR CONDITIONER	$60.0	$12.15	N/A	N/A	N/A
AIR START	$80.0	$33.76	N/A	N/A	N/A
BAG TUG	$15.5	$8.06	$29.4	$6.04	$2,500
BELT LOADER	$23.0	$6.63	$36.8	$4.97	$2,500
BOBTAIL	$24.0	$13.82	$36.8	$10.37	$2,500
BUS[2]	$110.0	$9.58	$114.0	$9.58	N/A
CAR[2]	$15.0	$2.10	$17.0	$2.10	N/A
CARGO LOADER	$150.0	$9.84	$189.0	$7.38	$2,500
CART	$6.0	$1.69	$6.0	$1.27	$2,500
DEICER	$5.0	$4.63	$5.0	$3.47	$2,500
FORKLIFT	$18.0	$10.32	$21.0	$7.74	$2,500
FUEL TRUCK[2]	$65.0	$16.83	$69.0	$16.83	N/A
GPU	$32.0	$10.44	N/A	N/A	N/A
LAV CART	$7.0	$2.44	$7.0	$2.44	N/A
LAV TRUCK	$35.0	$12.15	$44.1	$9.11	$2,500
LIFT	$45.0	$13.73	$56.7	$10.30	$2,500
MAINTENANCE	$25.0	$12.82	$31.5	$9.62	$2,500
TRUCK	$20.0	$10.97	$31.5	$8.23	$2,500
OTHER	$18.0	$9.65	$28.4	$7.24	$2,500
PICKUP	$25.0	$12.82	$31.5	$9.62	$2,500
SERVICE TRUCK	$22.0	$10.09	$24.0	$10.09	N/A
VAN[2]	$32.0	$14.04	$40.4	$10.53	$2,500
WATER TRUCK					

1 5% added to all electric GSE capital costs (per unit) for shipping the conventional piece of equipment (replaced by the electric piece) to a station outside of the FIP area for reuse. This does not apply to carts, deicers, lav carts, or on-road vehicles.

2 Capital and O&M costs are for ILEVs rather than electrics.

FIGURE 2-37: ANNUAL GSE CONVERSION COST SOUTH COAST AIR BASIN

Year	Capital Cost Difference $[(CC_E+CC_{ER}-CC_C)$ $\times EU_P]$	O&M Cost Difference $[(OMC_E-OMC_C)$ $\times EU_O]$	Total Annual GSE Cost (C)
1997	$9,110,300	$254,060	$9,364,360
1998		($1,548,440)	($1,548,440)
1999	$86,000	($1,548,440)	($1,462,440)
2000	$16,880,750	($1,690,300)	$15,190,450
2001		($3,935,300)	($3,935,300)
2002		($3,935,300)	($3,935,300)
2003		($3,935,300)	($3,935,300)
2004		($3,935,300)	($3,935,300)
2005	$10,090,775	($3,907,460)	$6,183,315
2006		($4,422,876)	($4,422,876)
2007		($4,422,876)	($4,422,876)
2008		($4,286,521)	($4,286,521)
2009		($2,831,513)	($2,831,513)
2010	$4,898,075	($2,863,145)	$2,034,929

NOTE: Cost abbreviations are in parentheses, based on the equation in the Annual GSE Conversion Cost discussion:

$$C_Y = (CC_E + CC_{ER} - CC_C) \times EU_P + (OMC_E - OMC_C) \times EU_O$$

Some costs are negative and, therefore, a savings.

**FIGURE 2-38: ANNUAL GSE CONVERSION COST
SACRAMENTO AIR BASIN**

Year	Capital Cost Difference $[(CC_E+CC_{ER}-CC_C) \times EU_P]$	O&M Cost Difference $[(OMC_E-OMC_C) \times EU_O]$	Total Annual GSE Cost (C)
1997	$958,900	$22,216	$981,116
1998		($165,284)	($165,284)
1999	$8,000	($165,284)	($157,284)
2000	$1,528,100	($197,197)	$1,330,903
2001		($384,697)	($384,697)
2002		($384,697)	($387,697)
2003		($384,697)	($384,697)
2004		($384,697)	($384,697)
2005	$768,700	($384,393)	$384,307
2006		($390,639)	($390,639)
2007		($390,639)	($390,639)
2008		($369,110)	($369,110)
2009		($251,186)	($251,186)
2010	$27,200	($250,655)	($223,455)

NOTE: Cost abbreviations are in parentheses, based on the equation in the Annual GSE Conversion Cost discussion:

$$C_Y = (CC_E + CC_{ER} - CC_C) \times EU_P + (OMC_E - OMC_C) \times EU_O$$

Some costs are negative and, therefore, a savings.

2.3.4 Capital Outlay Requirements and Cash Flow Analysis

The previous sections discussed the cost implications of the APU and GSE components of the IFR. To understand the full impact of the IFR on the regulated community it is helpful to know what the combined requirements mean for annual capital outlay and cash flow.

The net annual capital cost of the IFR, which is the basis of this analysis, is the total annual capital outlay, over capital required for normal operations, due to the IFR requirements. The net annual O&M cost is the difference between annual O&M costs after implementation of these rules and annual O&M costs under conventional operations. As noted, the APU and GSE rules result in substantial O&M savings. The sum of the annual capital outlay and annual O&M costs is the net cash flow resulting from this rule. This section describes the capital cost requirements for the APU and GSE components of the two rules combined and resulting net annual cash flow considering combined capital outlay and O&M cost savings.

The cumulative net capital cost of the APU and GSE IFR requirements combined for all airports in the South Coast Air Basin is $70 million and $5 million for Sacramento Metropolitan Airport. These are shown in Figures 2-39 and 2-40.

Combining the annual net capital requirements for the APU and GSE IFR requirements with annual O&M costs results in annual cash flow due to these requirements. Appendix 2-10 summarizes these calculations for each affected airport and the South Coast Air Basin as a whole. For the South Coast, the only year with a negative net cash flow is 1997 ($2.6 million) as shown in Figure 2-41. Every other year during the FIP control period has a positive cash flow due to the lower O&M costs primarily for APU operation. Sacramento shows a negative annual net cash flow in 1997, 1999, and 2000 with all other years to 2010 having a positive cash flow. This is shown in Figure 2-42.

FIGURE 2-39: IFR APU AND GSE REQUIREMENTS CASH FLOW ANALYSIS

SOUTH COAST AIR BASIN

YEAR	APU				GSE			
	Net Capital Outlay	Net O&M Outlay	Annual Net Cash Flow[1]	Cum Annual Cash Flow	Net Capital Outlay	Net O&M Outlay	Annual Net Cash Flow[1]	Cum Annual Cash Flow
1997		($6,795,644)	($6,795,644)	($6,795,644)	$9,110,300	$254,061	$9,364,361	$9,364,361
1998		($7,040,342)	($7,040,342)	($13,835,986)		($1,548,439)	($1,548,439)	$7,815,922
1999	$19,650,000	($21,111,853)	($1,461,853)	($15,297,839)	$86,000	($1,548,439)	($1,462,439)	$6,353,483
2000		($21,848,103)	($21,848,103)	($37,145,942)	$16,880,750	($1,690,299)	$15,190,451	$21,543,934
2001		($22,584,376)	($22,584,376)	($59,730,318)		($3,935,299)	($3,935,299)	$17,608,635
2002	$3,960,000	($24,001,022)	($20,041,022)	($79,771,340)		($3,935,299)	($3,935,299)	$13,673,336
2003		($24,760,803)	($24,760,803)	($104,532,143)		($3,935,299)	($3,935,299)	$9,738,037
2004		($25,520,584)	($25,520,584)	($130,052,727)		($3,935,299)	($3,935,299)	$5,802,738
2005		($26,280,366)	($26,280,366)	($156,333,093)	$10,090,775	($3,907,461)	$6,183,314	$11,986,052
2006		($27,040,146)	($27,040,146)	($183,373,239)		($4,422,875)	($4,422,875)	$7,563,177
2007		($27,799,927)	($27,799,927)	($211,173,166)		($4,422,875)	($4,422,875)	$3,140,302
2008		($28,559,710)	($28,559,710)	($239,732,876)		($4,286,521)	($4,286,521)	($1,146,219)
2009		($29,319,489)	($29,319,489)	($269,052,365)		($2,831,513)	($2,831,513)	($3,977,732)
2010		($29,961,872)	($29,961,872)	($299,014,237)	$4,898,075	($2,863,146)	$2,034,929	($1,942,803)

[1] Net Capital Outlay + Net O&M Outlay

NOTE: Negative costs are shown in parentheses and reflect a cost savings to the regulated community.

FIGURE 2-40: IFR APU AND GSE REQUIREMENTS CASH FLOW ANALYSIS

SACRAMENTO AIR BASIN

YEAR	APU				GSE			
	Net Capital Outlay	Net O&M Outlay	Annual Net Cash Flow[1]	Cum Annual Cash Flow	Net Capital Outlay	Net O&M Outlay	Annual Net Cash Flow[1]	Cum Annual Cash Flow
1997		($63,803)	($63,803)	($63,803)	$958,900	$22,216	$981,116	$981,116
1998		($66,316)	($66,316)	($130,119)		($165,284)	($165,284)	$815,832
1999	$1,870,000	($321,207)	$1,548,793	$1,418,674	$8,000	($165,284)	($157,284)	$858,548
2000		($329,441)	($329,441)	$1,089,233	$1,526,100	($197,197)	$1,330,903	$1,989,451
2001		($339,747)	($339,747)	$749,486		($384,697)	($384,697)	$1,604,754
2002	$330,000	($357,397)	($27,397)	$722,089		($384,697)	($384,697)	$1,220,057
2003		($368,075)	($368,075)	$354,014		($384,697)	($384,697)	$835,360
2004		($378,752)	($378,752)	($24,738)		($384,697)	($384,697)	$450,863
2005		($389,429)	($389,429)	($414,167)	$768,700	($384,393)	$384,307	$834,970
2006		($389,429)	($389,429)	($803,596)		($390,639)	($390,639)	$444,331
2007		($389,429)	($389,429)	($1,193,025)		($390,639)	($390,639)	$53,692
2008		($389,429)	($389,429)	($1,582,454)		($369,110)	($396,110)	($315,418)
2009		($389,429)	($389,429)	($1,971,883)		($251,186)	($251,186)	($566,604)
2010		($389,429)	($389,429)	($2,361,312)	$27,200	($250,655)	($223,455)	($790,059)

[1] Net Capital Outlay + Net O&M Outlay

NOTE: Negative costs are shown in parentheses and reflect a cost savings to the regulated community.

FIGURE 2-41: IFR APU AND GSE REQUIREMENTS
PASSENGER ANALYSIS
SOUTH COAST AIR BASIN

YEAR	Airport Total					
	Annual Net Cash Flow	Cum Annual Cash Flow	Annual Passenger Forecast[1]	Cum Passenger Forecast	Annual Net Cash Flow/ Passenger	Cum Cash Flow/ Passenger
1997	$2,568,717	$2,568,717	72,740,146	72,740,146	$0.04	$0.04
1998	($8,588,781)	($6,020,064)	75,026,573	147,766,718	($0.11)	($0.04)
1999	($2,924,292)	($8,944,356)	77,312,999	225,079,718	($0.04)	($0.04)
2000	($6,657,852)	($15,602,008)	79,599,426	304,679,144	($0.08)	($0.05)
2001	($26,519,675)	($42,121,683)	81,880,180	386,559,323	($0.32)	($0.11)
2002	($23,976,321)	($66,098,004)	84,160,933	470,720,257	($0.28)	($0.14)
2003	($28,696,102)	($94,794,106)	86,441,687	557,161,943	($0.33)	($0.17)
2004	($29,455,883)	($124,249,989)	88,722,440	645,884,384	($0.33)	($0.19)
2005	($20,097,052)	($144,347,041)	91,003,194	736,887,578	($0.22)	($0.20)
2006	($31,463,021)	($175,810,062)	93,283,947	830,171,525	($0.34)	($0.21)
2007	($32,222,802)	($208,032,864)	95,564,700	925,736,225	($0.34)	($0.22)
2008	($32,846,231)	($240,879,095)	97,845,454	1,023,581,679	($0.34)	($0.24)
2009	($32,151,002)	($273,030,097)	100,126,207	1,123,707,886	($0.32)	($0.24)
2010	($27,926,943)	($300,957,040)	102,406,960	1,226,114,846	($0.27)	($0.25)

[1] Estimated based on air basin growth rates and data from FAA's 1990 *Airport Activity Statistics of Certificated Route Air Carriers* (Reference 14). Linear growth between forecast years was assumed.

NOTE: Negative costs are shown in parentheses and reflect a cost savings to the regulated community.

FIGURE 2-42: IFR APU AND GSE REQUIREMENTS
PASSENGER ANALYSIS
SACRAMENTO AIR BASIN

YEAR	Airport Total					
	Annual Net Cash Flow	Cum Annual Cash Flow	Annual Passenger Forecast[1]	Cum Passenger Forecast	Annual Net Cash Flow/ Passenger	Cum Cash Flow/ Passenger
1997	$917,313	$917,313	3,989,662	3,989,662	$0.23	$0.23
1998	($231,600)	$685,713	4,063,313	8,052,975	($0.06)	$0.09
1999	$1,391,509	$2,077,222	4,136,964	12,189,939	$0.34	$0.17
2000	$1,001,462	$3,078,684	4,210,615	16,400,554	$0.24	$0.19
2001	($724,444)	$2,354,240	4,222,427	20,622,981	($0.17)	$0.11
2002	($412,094)	$1,942,146	4,234,239	24,857,219	($0.10)	$0.08
2003	($752,772)	$1,189,374	4,246,050	29,103,270	($0.18)	$0.04
2004	($763,449)	$425,925	4,257,862	33,691,132	($0.18)	$0.01
2005	($5,122)	$420,803	4,269,674	37,630,806	($0.00)	$0.01
2006	($780,068)	($359,265)	4,341,241	41,972,047	($0.18)	($0.01)
2007	($780,068)	($1,139,333)	4,412,807	46,384,854	($0.18)	($0.02)
2008	($758,539)	($1,897,872)	4,484,374	50,869,228	($0.17)	($0.04)
2009	($640,615)	($2,538,487)	4,555,940	55,425,168	($0.14)	($0.05)
2010	($612,884)	($3,151,371)	4,627,507	60,052,675	($0.13)	($0.05)

[1] Estimated based on air basin growth rates and data from FAA's 1990 *Airport Activity Statistics of Certificated Route Air Carriers* (Reference 14). Linear growth between forecast years was assumed.

NOTE: Negative costs are shown in parentheses and reflect a cost savings to the regulated community.

Figures 2-41 and 2-42 also show total capital outlay and net cash flow on a per passenger basis for the South Coast and Sacramento. This data is presented on both an annual and a cumulative basis for the South Coast and for Sacramento. The passenger forecast is developed on the same basis as the LTO forecast used as a measure of activity. The 1990 passenger enplanements reported in FAA's *Airport Activity Statistics of Certificated Route Air Carriers* (Reference 14) are for the operations of domestic carriers. The 1990 average number of enplanements per LTO was calculated by dividing the total number of 1990 enplanements by the total number of 1990 LTOs for each airport. For each airport, the average number of enplanements per LTO then was multiplied by the number of LTOs 1990 reported by the airport but not included in the FAA report to estimate the number of enplanements for these "other" operations. These "other" operations include any foreign carrier operations at the airport, whether scheduled or charter, since foreign carrier operations are not reported in the FAA report but are provided in airport data. Finally, domestic carrier and "other" 1990 passenger enplanements were totalled and multiplied by two to get the total number of passengers (enplaned and deplaned) for each airport. Each airport's 1990 total number of passengers was escalated by the SCAG forecast growths for South Coast airports and Sacramento Department of Airports forecast growth for Sacramento airports (see Figure 2-19) to obtain passenger forecasts.

In the South Coast, the combined cost of implementing the APU and GSE requirements results in a maximum annual cost of only $0.04 per passenger in 1997. All other years result in a cost savings as high as $0.33 per passenger in 2003 and 2004. For Sacramento, these rules cost a maximum of $0.34 per passenger in 1999. Savings in a given year never exceed $0.18 per passenger, however, the cumulative cash flow per passenger over the control period reflects a cost savings.

3. PROGRAM ELEMENT - GENERAL AVIATION

3.1 GENERAL AVIATION CHARACTERIZATION

The general aviation (GA) category consists of privately-owned aircraft operated under FAA Parts 91, 133, or 137. As such, it encompasses aircraft types with significantly different engines, including piston, turboprop, and turbine. Most general aviation aircraft are owned and operated by private individuals and are based at a variety of facilities throughout the South Coast air basin. Much of the general aviation fleet is old, with few significant technological improvements in emissions performance expected in the foreseeable future.

General aviation aircraft operate at a variety of facilities in the control areas, ranging from large commercial airports to small privately-owned airstrips and helipads. (See TSD reference for a list of the civil airfields capable of aircraft operations in the control areas.) FAA data for 1991 lists 198 helipads in the South Coast control area, 11 helipads in the Sacramento control area, and 12 helipads in the Ventura control area; this includes private helipads, medical facilities, and various local government facilities.

Sales of piston-engine aircraft, the dominant general aviation aircraft type, have declined dramatically in recent years, from a 1978 peak of over 17,000 to just 526 aircraft sold in 1992, according to FAA and Aerospace Industry Association statistics. This decline has resulted from a number of factors, including substantially higher ownership costs (in particular product liability costs), general economic trends, and regulatory concerns. It is important to note, however, that general aviation activity has remained relatively stable over this same time period both nationally and in California, according to FAA data. Existing general aviation aircraft thus continue to operate at essentially unchanged rates. Coupled with the dramatic decline in sales, this suggests that older aircraft are not being retired, and therefore that the general aviation fleet is aging without significant turnover to new aircraft.

Limited information is available concerning emissions resulting from general aviation activity, although these emissions are expected to be small relative to those resulting from commercial and military aircraft operations. The FAA collects some information on general aviation operations and based aircraft at airports with FAA-operated (or contractor-operated) control towers, but this data is not comprehensive, and does not capture operations occurring at non-tower-controlled facilities.

3.2 SUMMARY OF ORIGINAL PROPOSAL

3.2.1 Summary of Proposal

The proposed FIP control strategy for general aviation was to impose operations fees on each takeoff in a FIP area to reduce the emissions from general aviation aircraft through activity reduction. No specific emissions cap or reduction target was specified. Data on aircraft population and activity is limited and there are very many owners/operators of general aviation aircraft, which makes tracking and enforcing a fixed level of emissions or activity extremely challenging. National emission factors for new general aviation aircraft engines were considered but the increasingly slow fleet turnover limits the benefits that can be gained through new equipment.

3.2.2 1990 GA Emissions Inventory

A summary of GA emissions for 1990 is presented in Figure 3-1. See the 1994 TSD (Reference 7) for a discussion of the calculation methodology used to develop this summary. This inventory employs a generalized emission factor compiled from a representative GA fleet mix. Emissions were not calculated on an airport-by-airport basis, but for the FIP areas as a whole.

FIGURE 3-1: SUMMARY OF GA AIRCRAFT EMISSIONS - 1990
(lb/yr)

Air Basin	LTOs	HC	NO_x
South Coast	2,024,000	1,754,178	131,560
Sacramento	168,602	128,371	10,959
Ventura	179,000	170,517	11,635

3.2.3 Uncontrolled GA Emissions Forecast

Figure 3-2 provides GA emissions by pollutant and year for each control area. See the 1994 TSD (Reference 7) for a discussion of the calculation methodology used to develop this summary.

FIGURE 3-2: SUMMARY OF GA AIRCRAFT EMISSIONS FORECAST
(lb/yr)

SOUTH COAST AIR BASIN				
Pollutant	**1990**	**2000**	**2005**	**2010**
HC	1,754,178	1,994,500	2,148,868	2,299,727
NO_x	131,560	149,584	161,161	172,475

SACRAMENTO AIR BASIN				
Pollutant	**1990**	**1999**	**2000**	**2005**
HC	128,371	153,681	156,804	173,453
NO_x	10,959	12,809	13,035	14,231

FIGURE 3-2: SUMMARY OF GA AIRCRAFT EMISSIONS FORECAST (cont.)
(lb/yr)

VENTURA AIR BASIN			
Pollutant	**1990**	**2000**	**2005**
HC	170,517	203,452	211,289
NO_x	11,635	13,943	14,788

3.2.4 Emission Limits

There were few regulatory options available for reducing emissions from general aviation aircraft given the age and emissions performance of the general aviation fleet, and the economic status of the general aviation industry. There are no substantially cleaner alternatives to current technology engines for the vast majority of the fleet. Operational and procedural measures such as reduced-power takeoffs and direct routing from hardstand to runway would be difficult to implement for general aviation on an area-wide basis, given the widely varying aircraft and facility characteristics found in the control areas.

The only available measures for general aviation that would provide significant emission benefits thus involve activity reductions. Such reductions could be achieved in several ways: a slot program could be established for general aviation operations in the control areas with strict limits on the number of operations that can occur during a specified control period; a per-operation fee for general aviation could be established with the intention of discouraging excessive GA activity; or an environmental surcharge could be imposed on the sale of aviation fuel, also with the intention of discouraging excessive GA activity.

3.3 COMMENTS ON PROPOSAL

The industry, public, and other interested parties were asked to comment on the proposed regulation. The following represent the comments of primary importance to the technical aspects of the proposed rule:

- Most commentors indicated that general aviation operations contribute an insignificant amount of air pollutant emissions in the FIP control areas that do not warrant imposition of a control program, and several mentioned helicopter operations in particular as producing very limited emissions in normal circumstances.

- Several commentors stated that there has been a decline in activity and ownership statewide; since 1990 the operations (and consequently emissions) decline is significant. According to the Airline Owners and Pilots Association (AOPA), a national association that represents a large part of the general aviation community, there has been a 32% decline in flight hours since 1990 and a 15% decline in active based aircraft between 1990 and 1992 statewide - more like 25% in Southern California. While these reductions are not permanent they reflect the potential fragility of general aviation activity.

- The General Aviation Manufacturers Association questioned EEA's forecast of GA emissions, which showed a slight increase over the control period. The Association projected emissions reductions of 0.92 ton of VOC and 0.24 ton of NO_x by 2005 as the result of continued general aviation activity reductions.

- The General Aviation Manufacturers Association stated that limiting GA operations would not affect evaporative hydrocarbon emissions, which comprise more than 50 percent of GA "unburned" hydrocarbon emissions. The Association recommended controlling such evaporative emissions by improved fuel handling techniques such as collecting vapors while aircraft are parked, capturing and disposing of fuel drained from aircraft fuel tanks during preflight inspections, and recovering vapors during fuel transfer from storage tanks to fueling trucks and aircraft.

- The General Aviation Manufacturers Association stated that fuel efficiency and emissions reductions have improved over the past several years through general aviation industry self-regulation such as reduction of idle inefficiencies, investments to reduce engine emissions levels, and development of advanced ignition technology.

- Many commentors indicated that the imposition of a fee or other program designed to limit general aviation operations would compromise safety by reducing the number of training and practice flights available to pilots.

- FAA, in its comments to the docket, indicated its willingness to promote educational programs to (1) minimize emissions from fuel transfer or spills and (2) improve fuel mixture management during idling to maximize efficiency and minimize emissions. They also indicated that recapturing HC emissions from aircraft fuel tank vents is feasible and acceptable. The General Aviation Manufacturers Association (GAMA) made similar suggestions.

3.4 EMISSION MITIGATION OPPORTUNITIES

Direct regulation of the general aviation category is being dropped. Certain emission mitigation opportunities can be pursued for general aviation operations in the absence of a regulatory program, however.

The FAA indicated in the Department of Transportation's comments that it is willing to provide educational programs to minimize emissions resulting from fuel transfer or spills, to improve fuel mixture management during idling, and to returning uncontaminated fuel to the main tanks after pre-flight testing. FAA indicated that capturing VOC emissions from general aviation aircraft fuel tank vents while the aircraft is parked idle is a feasible emissions control measure that could reduce VOC emissions from GA operations by 20 percent or more. FAA's recent comments on opportunities for reducing emission from general aviation aircraft appear in Appendix 2-11.

The General Aviation Manufacturers Association recommended controlling such evaporative emissions by improved fuel handling techniques such as collecting vapors while aircraft are parked, capturing and disposing of fuel drained from aircraft fuel tanks during preflight inspections, and recovering vapors during fuel transfer from storage tanks to fueling trucks and aircraft.

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